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Some Developments in Metal Melting and Heating Furnaces

The increasing demand for better and cheaper products has involved considerable development in melting and heating equipment, and this article reviews some furnaces in which progress has been made. Only a brief survey has been attempted.

MODERN production standards in regard to quality of product, output, and low cost have been responsible for considerable development in furnace design during recent years. Keen competition during the period of depression has undoubtedly assisted in the progress because it has necessitated the exploration of all avenues likely to lead to improved or cheaper production.

In some instances relatively little change in design had been effected since their inception, but it was recognised that any progress made in the development of metals and alloys must be governed to some extent by the furnace or furnaces through which they were passed. It is not proposed to deal with these developments in a comprehensive way, but rather to indicate some recent examples that indicate the concentrated effort being applied by responsible firms to meet modern conditions.

In the iron foundry the cupola has long been appreciated as the most economical melting unit, and with accumulated experience gained during years of operation it is remarkable what good results can be and are being obtained from this type of furnace. It is true that many modifications have been incorporated with the design of these furnaces in order to effect better combustion, but the principle involved remains unaltered. The most recent and notable development of the cupola furnace is that made by Fletcher[1]. This cupola is designed with a row of main tuyères and two or more rows of smaller auxiliary tuyères, all of which are in and fed from the same wind belt. The special feature of this cupola is that the main or lowest row of tuyères are controlled by finely adjustable screw valves, so that the air admitted to these tuyères may be regulated. Although the annular stream of air passing the valves may be at a high velocity, the tuyère apertures between the valves and the cupola lining are so designed that the impinging effect on the coke is reduced to produce a softer blast. Many cupolas of this design are in use, and in all but special cases a melting ratio of 14 to 1 of metal to coke charged is obtained.

It has been considered by many that direct contact between the fuel and metal should be avoided as much as possible, since the iron absorbs deleterious elements from the coke, and in order to secure greater atmosphere control. With this object two types of rotary pulverised-fuel melting furnaces have been put into operation in this country. One of these is the Sesci type, in which the outstanding features are shortness of flame, concentrated intense heat, and efficient preheating of the combustion air by the exhaust gases. The other is the Brackelsberg melting furnace. In this furnace the melting process is facilitated by the high temperature of the coal-dust flame, its uniform spread in the furnace chamber, and its excellent heat-transmission to the charge. There can be no doubt that these furnaces offer distinct possibilities in the production of high quality cast iron and malleable iron, and they are being used with considerable success.

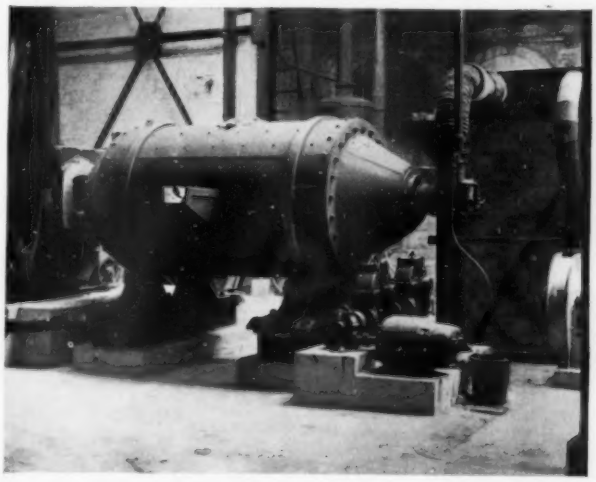


Fig. 1.—Oscillating furnace for melting special irons.

The Stein and Atkinson oscillating furnace for melting special irons, shown in Fig. 1, has recently been introduced into this country, having been thoroughly tried out under practical conditions on several installations in France, and marks an important development in the control of the quality of special irons and the manufacture of intricate or high quality castings. This type of furnace can also be used for superheating the metal obtained from the cupola. It is oil-fired and the metal is not in intimate contact with carbon during the melting; it is protected by a film of slag so that oxidisation is prevented, resulting in low metal loss. The plant is simple, and, compared with a pot-fired furnace, less expensive in initial outlay, more reliable in operation, and lower in maintenance cost.

A range of these furnaces has been standardised in capacities of from ½ ton to 3 tons capacity, and introduced by Messrs. Stein and Atkinson, Ltd. An interesting feature claimed for them is that they "cast soft" so that for the same hardness iron melted in this rotary furnace may, in general, have a lower carbon content than metal melted in the cupola, thus a high proportion of steel may be used in the charge.

Furnaces of this type, in addition to melting malleable and mechanical cast iron both in "Simplex" and "Duplex" working, are being used for making high-test pearlitic iron, chrome-nickel-copper irons, and for mill-roll making, as

[1] Recent Developments in Cast Iron and Foundry Practice in Great Britain, by J. G. Pearce, METALLURGIA, June, 1931, p. 56.

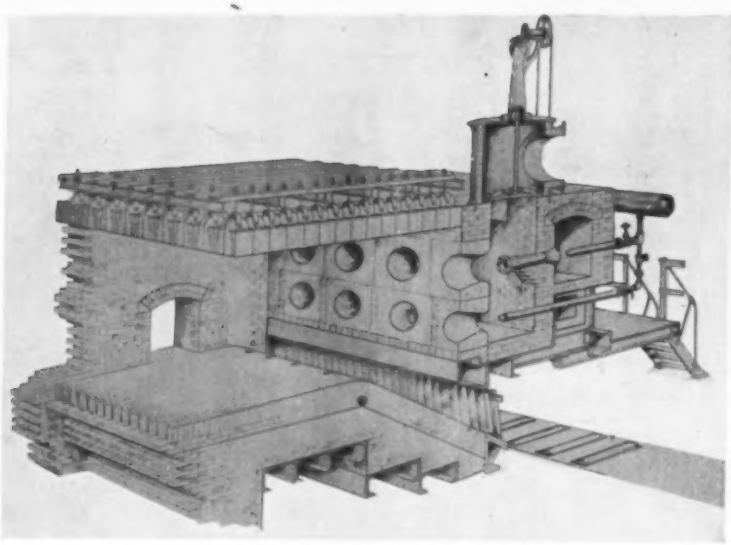


Fig. 2.—Continuous furnace for rolling-mill use with special burners arranged in two banks.

well as for small steel castings. They are also in use for melting brass, bronze, nickel-bronze, nickel-silver, and similar alloys, as well as for copper refining. The furnaces are fully recuperative and a metal temperature of 1,700° C is readily obtained. Working under normal conditions bronze turnings are melted down for a fuel consumption of 5·4% (13½ gals. per ton), and a melting loss of 1·25% (this loss is only 0·75% when melting ingots). Cast iron is commonly melted and tapped at 1,600° C. for a fuel consumption of 17% to 19% (42 to 47 gals. per ton) in from one hour to one hour 30 minutes and for a melting loss of 1 to 2%.

A recent development in melting furnaces is the "Foster" patented furnace by British Furnaces, Ltd., designed for melting copper and aluminium alloys in a short time with low expenditure of fuel. It is a gas-fired tilting furnace in which the metal is charged direct into the combustion chamber. A feature of this furnace is the unique recuperator mounted above two flues, which provides a supply of hot air to the burner and assists in making the furnace economical in use.

Attention may also be directed to the melting furnaces recently exhibited at the Birmingham section of the British Industries Fair and referred to in our February issue. One of these is a semi-rotary furnace by Sir W. G. Armstrong Whitworth and Co. (Engineers), Ltd., which has been modified by the introduction of a tapping valve. Another rapid and economical melting furnace is that which was exhibited by British Reverberatory Furnaces, Ltd., which has been modified somewhat to ensure better balance when tilting, and also to improve the efficiency of the air preheating system incorporated in the design. The Morgan Crucible Co., Ltd., also exhibited an oil-fired tilting crucible furnace of improved design. Mention may also be made of two 20,000 lb. aluminium coke-fired furnaces built by Priest Furnaces, Ltd., and installed by an important firm. These were built on modern lines.

Of recent developments in furnace design, probably more attention has been directed to heating and heat-treatment furnaces in which any one of a number of fuels or electricity has been used as the heating medium. It is becoming more generally realised that if the best results in regard to quality of materials are to be obtained, the heating units used must have special attention; particu- is this the case with pulverised coal, oil, and gas. For these the burners, the furnace, and the controls must be considered and designed as a whole and not as a furnace to which a burner, probably of an unsuitable type, can be connected, more or less as an afterthought. It is because this fact is now appreciated that progress has become more rapid.

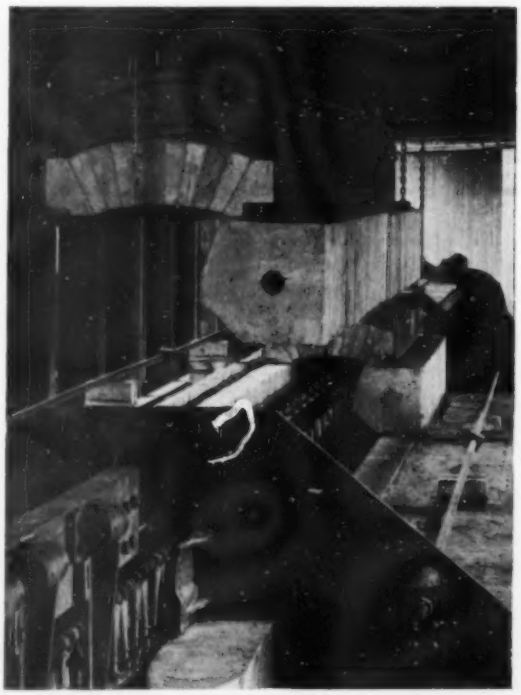
A design of continuous furnace for rolling-mill use is shown in Fig. 2, in which Stein pressure burners are arranged in two banks. The upper or "tonnage" burners give a high temperature free-burning flame which heats the stock by radiation. The lower or "conditioning" burners maintain a blanket of slightly reducing flame over the stock to protect it from scaling. Furnaces using these burners have been built to heat blooms up to 42 ft. 6 in. long, and giving perfect control through a range of outputs from 5 to 65 tons per hour from the same furnace. The whole of each bank of burners is regulated by a single-blast control valve. Fuel consumptions below 100 lb. of coal per ton of steel heated to rolling temperature are recorded, and 120 lb. per ton is an average figure, including week-end stand-by.

The same type of burner is used for recuperative soaking pits. These are one-way fired, with a downward travelling horseshoe flame. Fuel consumptions and scale losses are much lower than with a reversing regenerative type of pit, output is increased, operation is easier, and the units are far more compact and very flexible in operation. Although newly introduced in this country there are 50 of these pits in operation.

Mention may also be made of the Griffiths vertical normalising furnace recently developed, a part illustration of which is shown in Fig. 3. Tests on this furnace have demonstrated that it can be simply adapted for the normalising of tin plates in addition to sheets. Recent results showed excellent normalising, and there is every prospect of this type finding extensive use in tinplate work.

The use of surface combustion low pressure burners in specially designed furnaces for heat-treatment operations by British Furnaces, Ltd., is shown in Fig. 4. This is designed on the established principle that when gas and

Fig. 3.—Part illustration of vertical normalising furnace.



air, mixed in the correct ratio for complete combustion, are burned so that the flame impinges on a bed of broken refractory material, combustion is greatly accelerated and the refractory bed radiates considerable heat, due to the large surface exposed and to its high temperature. Either single or two-stage burners may be used; the latter mix the gas and air in two operations in order to give exact proportions for complete and perfect combustion.

This firm has supplied a large town's gas-fired billet-heating furnace, 29 ft. long, to a tube-manufacturing firm for the heating of stainless steel billets for the making of tubes by the extrusion process, and the surface combustion burner system has been found particularly suitable.

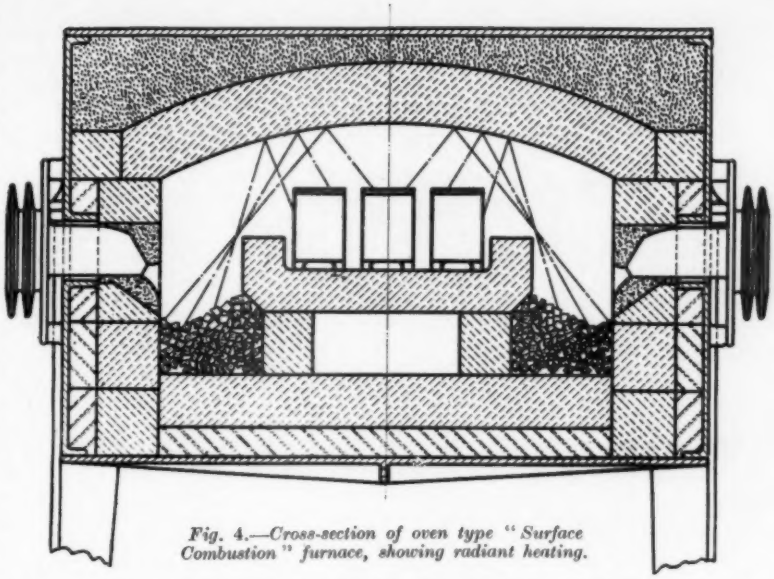
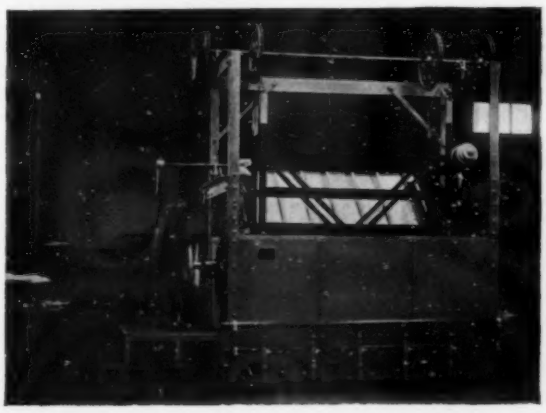


Fig. 4.—Cross-section of oven type "Surface Combustion" furnace, showing radiant heating.

Considerable attention has been given to the design of furnaces for the heat-treatment of aluminium alloys used for aircraft, etc. A recent gas-fired salt-bath furnace for this purpose is illustrated in Fig. 5. It is one of the designs by Brayshaw Furnaces and Tools, Ltd., and the inside measurement of the bath is 7 ft. by 2 ft. by 4 ft. deep. It is heated by burners arranged for town's gas in conjunction with air at about 20-in. water gauge pressure. A counterbalanced cover and a rising and falling platform of special design are embodied. The cover is counterbalanced in such a way that by a slight effort it swings and tilts up at the rear of the furnace. In the open position it presents a cool top to the operator, instead of the hot underside, and when it descends there is no rush of hot air to the front of the furnace. An automatic counterbalance is arranged in conjunction with the rising and falling platform so as to compensate for the loss in weight as the work is lowered into the liquid. The raising and lowering is performed by means of a capstan wheel and gearing so that the load of work is easily dealt with, being correctly counterbalanced both when in the liquid and when it is lifted clear above the bath.

During the past year Burdens, Ltd., have developed a furnace for the annealing of chains which has proved very economical and produces an excellent product. It is designed for oil firing. Owing to the new Board of Trade Regulations with reference to chain annealing, this furnace can be guaranteed to heat every link to a uniform temperature, and is claimed to be a great advancement for this particular class of work. The bogie on which the chain is charged is made in such a fashion that the brickwork becomes part of the furnace, the flame passing through the bogie brickwork and up through the load of chain, at the same time passing upwards from the bogie in front of the door. The method was only arrived at after considerable experiments and expense. The temperature is controlled by means of a thermostat which is set by a master valve to pass the requisite amount of oil necessary to maintain a specific temperature.

Fig. 5.—Gas-heated salt-bath furnace for the heat-treatment of aluminium alloys.



A new process of continuous gas carburising has been introduced by British Furnaces, Ltd., that is of considerable interest. This process has three zones in which the reactions are carbon deposition, active carburisation, and carbon diffusion, respectively. The furnace in which the process is used is of the muffle type, and the carburising gas is passed into the muffle so as to flow through in the same direction as the work to be carburised.

Under the catalytic effect of the steel to be carburised, the hydrocarbon gas cracks in the first (low-temperature) zone of the furnace. The breakdown of this gas is not complete, but only sufficient to cover the work uniformly with a deposit of free carbon, which adheres to the work. This breakdown is regulated by the rate of flow of gas through the first zone, and the deposition of carbon is so controlled that it occurs on the surface of the work rather than on the walls of the muffle. In the second, or full-temperature zone of the furnace, the carbon dioxide of the carburising medium becomes effective. It is in this zone that active carburisation takes place and the reaction is very energetic, the essential carburising reactions being obtained right at the surface of the metal.

Rapid carburising is, of course, apt to cause a sharp demarcation between the case and the core, so that if the process stopped there would be trouble in service. For this reason there must be a third, or diffusion, zone. In this, the diffusion zone, the atmosphere is of great importance, as the process is controlled by regulating the composition of the gases in this zone. Also, under conditions existing in this zone, the carbide case diffuses towards the inner core, so that the carbon may be further cooled or quenched as desired.

The effect of the reactions is shown in the photomicrographs, Fig. 6, in which A is taken from a specimen 3 ft. from the entrance to the muffle, and shows carbon deposition and the beginning of carburisation; B is taken from a specimen in the centre of the carburising zone and shows the case and core rather sharply defined as a result of insufficient carbon diffusion; the completed case is shown by C taken after the specimen had passed through the diffusion zone. A general view of a continuous gas carburising furnace operating on this system is shown in Fig. 7.

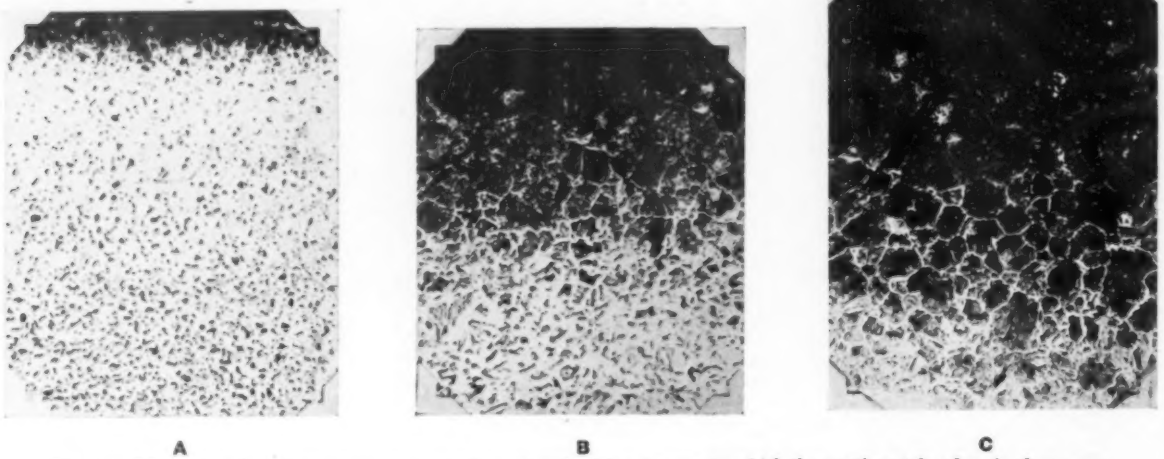
A modification has been made in a recently installed "Revergen" forging furnace by the Davis Furnace

Company. Contrary to the usual practice, the regenerators of this furnace are situated above the heating chamber, and the flames project downwards and across the floor of the furnace instead of upwards and under the arch. It is essential in this type of furnace that a permanent opening be provided, in the form of a slot, on one or both sides of the furnace, and unless special precautions are taken to prevent the products of combustion taking the line of least resistance and escaping through the slot to the open air, instead of by way of the regenerators, the efficiency of the furnace is greatly impaired. In the overhead type of this furnace the ports, on which the flames are formed, are situated above the top of the slot opening, and provision is here made for the furnace itself to draw the products away through the regenerators just as fast as they are produced.

A special feature of the overhead type of furnace is that the floor of the forging chamber, which is subject to heavy wear and tear, can easily be replaced, and maintenance is a low figure. This type of furnace is suitable for repetition work of a fairly continuous output. The controls shown in Fig. 8 are an important feature.

Considerable attention has been given to atmosphere-control operations, and all designers have given this question careful thought with a view to eliminating defects in the products of the furnaces. Thus, in the recuperative furnace of the radiant-wall type by the International Furnace Equipment Co., Ltd., the atmosphere has been so controlled that it is claimed that scaleless annealing is accomplished without the use of pots. Great turbulence is produced in the combustion chamber of this type of furnace, with the result that a very intimate mixture of oil and air is obtained, and the resultant products of combustion are led equally to all parts of the heating chamber.

The design of this furnace, a section of which is shown in Fig. 9, embodies the radiant-wall system of construction, together with automatic control of temperature and



A B C

Fig. 6.—Effect of carburising process in a continuous carburising furnace in which the reactions take place in three zones.

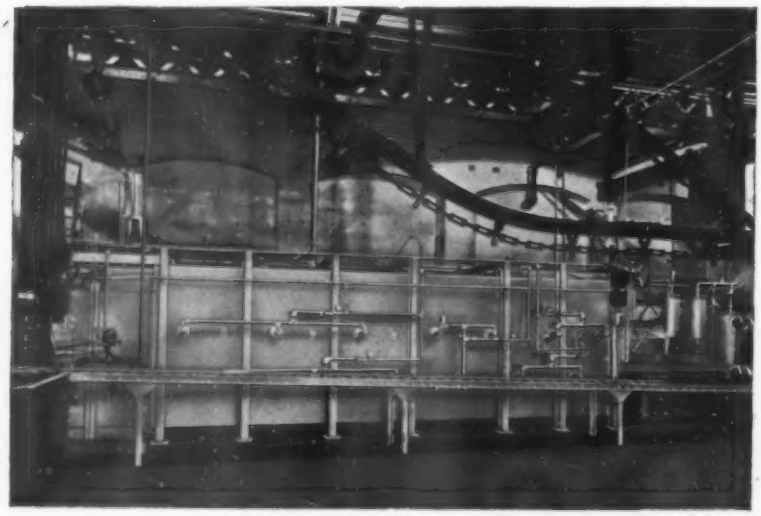


Fig. 7.—Continuous carburising furnace.

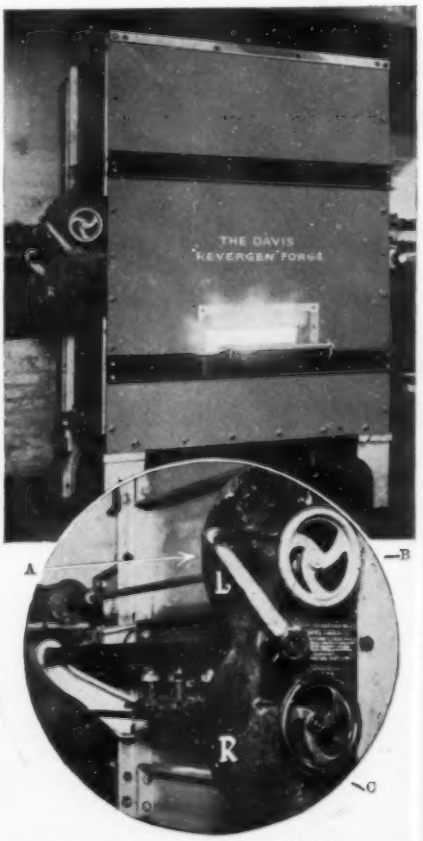


Fig. 8.—Forging furnace with the regenerators situated above the furnace.

A—Flame Reversing Lever. B—Air Control. C—Gas Contr[illegible]

atmosphere. When the controls have been set at predetermined values the furnace is claimed to operate without attention and with accuracy. The controls enable an oxidising or reducing atmosphere to operate in the furnace, according to requirements, which is of value in heat-treatment operations of both ferrous and non-ferrous metals.

The mechanical handling of material to be treated in furnaces has made considerable headway, and many furnaces are designed to convey the material through them. Several recent designs by Gibbons Bros., Ltd., show

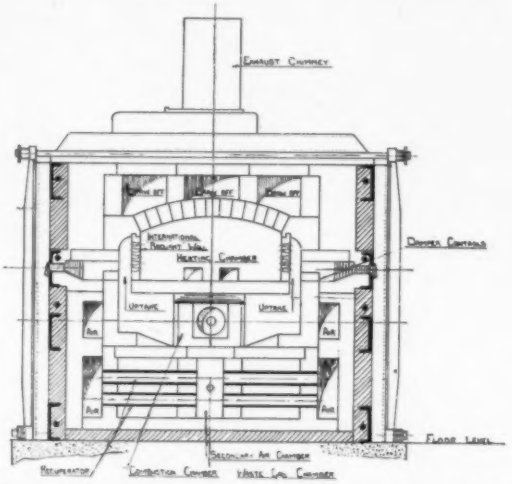


Fig. 9.—Section of furnace showing radiant-wall system of construction.

mechanical handling developed to a high degree. The Dowson and Mason Gas Plant Co., Ltd., have also recently built several heat-treatment furnaces in which the material is mechanically handled. In two of these it is conveyed through the furnace on walking beams, while in other furnaces that have recently been built by this firm for heating the ends of gear cases, the cases are carried along

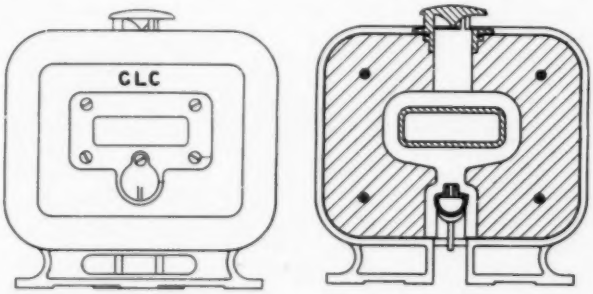


Fig. 10.—A new muffle soldering stove.

on a conveyer between two furnaces or alongside the furnace with the ends of the gear cases projecting into the furnaces.

Of considerable interest was an oil-fired heat-treatment furnace exhibited at the Birmingham section of the British Industries Fair by the Manchester Furnaces, Ltd. This has a heating chamber, 3 feet long, 2 feet wide, and 1 foot high. A recently designed oil burner is used for firing this furnace, and a small motor-driven fan is mounted at the back of the furnace for low-pressure air supply utilised for atomisation. An air-heating unit is built into the furnace structure to ensure maximum utilisation of waste heat to obtain a high preheat of atomising air supply. To obtain correct furnace atmosphere the burner is mounted on an air director fitted with a sliding shutter which controls the induced air.

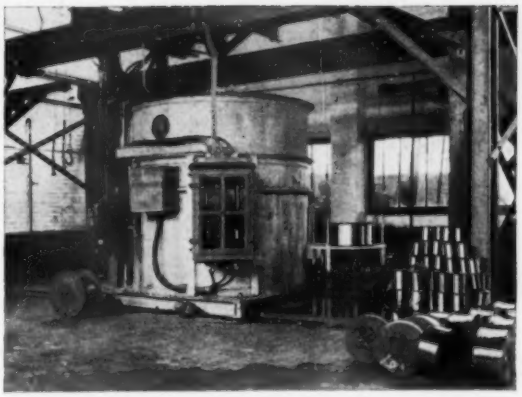


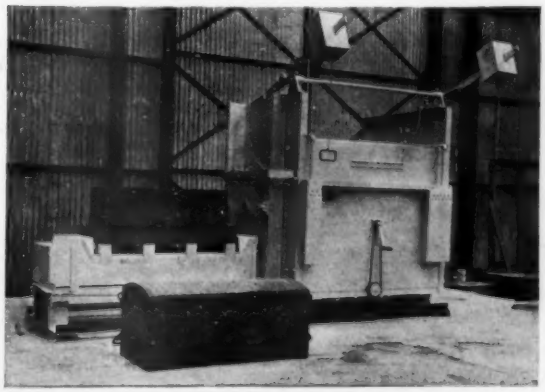
Fig. 11.—"Birlec" bright-annealing furnace for copper wire, showing hearths in raised condition.

A standard patent oil-fired complete muffle furnace by the Incandescent Heat Co., Ltd., suitable for operating at all temperatures up to 1,400° C., is fitted with a new type of burner. It is a low-pressure burner operating on gravity supply and low-pressure air. Preheated secondary air is admitted to the combustion chamber, which is operated with a minimum lead over the temperature operating in the muffle. In this design it is claimed that low live gas velocities are assured, and there is no scouring of the brickwork or ports and no deposition of carbon on the brickwork. The recovery of waste heat is a particular feature of this furnace, which is imparted to the secondary air for combustion. This unit is insulated and completely encased in heat-resisting cast-iron plates of ample section.

Attention may be directed to new type gas-fired muffle furnaces recently patented by the Gas Light and Coke Co., and manufactured by the Selas Gas and Engineering Co., Ltd., under licence. One of these is made in two types and six sizes, one type being suitable for operation at temperatures up to 1,000° C., and the other up to 1,250° C. The smaller sizes are suitable for laboratory and experimental work, while the larger sizes are suitable for productive work as well as experiments and tests on a bigger scale. The internal dimensions of the muffle of the smallest size are 4 in. by $2\frac{3}{4}$ in. by $2\frac{1}{2}$ in., while the largest of the series has a muffle 15 in. by 11 in. by 6 in. A muffle soldering stove is the other new type heating appliance, which has been specially designed for cleanly and economically heating small soldering irons. This soldering stove, two views of which are shown in Fig. 10, is the result of very careful research with a view to the maintenance of a constant temperature without overheating. The muffle will accommodate three small bits at one time.

Electric energy has come into wide use as a source of heat for manufacturing purposes, and during recent years

Fig. 12.—"Birlec" semi-continuous nitriding furnace, showing one container with cover removed for charging.



much progress has been made in the design of furnaces utilising this heating medium. Probably the important application of electricity for melting purposes is the introduction of induction furnaces, particularly in the wrought-brass industry. Robiette[2] has drawn attention to the possibilities of the coreless induction furnace for superheating cast iron as well as for metals and alloys. According to Pölzguter[3] the induction furnace is also well suited for finishing steel (carburisation, desulphurisation, deoxidation), and he considers it to be the best melting unit, especially for carbon-free alloys. The development of high-frequency furnaces has resulted in application of electric energy for the production of tool steel that is comparable with the best grades of crucible tool steel. It is probable, however, that the wider application of this heating medium has been in connection with heat-treatment operations, and in addition to furnaces designed for this purpose, referred to in the February issue of METALLURGIA, many other new designs have been applied to industrial purposes.

In these furnaces also attention has been directed to accurate control of temperature and atmosphere, and

Fig. 13.—"Birlec" forced air circulation spring plate tempering furnace.

bright annealing is now being accomplished in continuous furnaces. This is undoubtedly the most important of recent developments. Bright annealing, which has assumed considerable importance owing to the great economies effected by cutting out pickling, washing, and drying, and by eliminating metal losses through scaling and retaining the high finish of the metal surface, is only possible in a heating atmosphere free from oxygen. It has been shown that cracked ammonia gas, which is quite free from oxygen, and is perfectly dry, is eminently suitable for bright-annealing operations. A simple and reliable apparatus for cracking or decomposing anhydrous ammonia has been developed by Imperial Chemical Industries, Ltd. For many metals, however, it has been proved that a suitable atmosphere for ensuring bright annealing is a nitrogen-hydrogen mixture, the hydrogen content being between 4 and 10%. To obtain such a gas mixture Imperial Chemical Industries, Ltd., have devised an ammonia burner, which operates without the aid of external heat energy and provides a nitrogen-hydrogen mixture with a low hydrogen content.

The General Electric Co., Ltd., have developed a bright-annealing furnace for dealing with strip. The design and arrangement ensure uniform treatment of the strip, while the temperature can be accurately adjusted and maintained automatically. A nitrogen-hydrogen atmosphere is employed with the furnace, from an I.C.I. ammonia burner.

An interesting furnace for bright-annealing operations has recently been built for cable work in Belgium by Birmingham Electric Furnaces, Ltd. It is designed for bright-annealing coils of copper wire, and is giving economical and satisfactory results. Steam is used to exclude air from the heating chamber, and the work is quenched direct from the furnace without exposure to the air. The heating chamber is of "bell" form and is supported over the quenching pit. Two hearths are provided and are suspended from a travelling hoist, so that they may be lowered into the pit and moved so that either one may be lifted into the furnace chamber. The latter is kept filled with steam from the works main, a relief valve being provided in the top of the chamber to limit the pressure to a low value.

A hearth is charged, submerged, and raised into the furnace—the second hearth being simultaneously raised into position for loading. When the first charge is annealed it is lowered into the quench pit, and both hearths are moved laterally so that the fresh charge is in position for entering the furnace. The hearths are then raised so that the annealed work can be removed and replaced with fresh material while the second charge is being annealed. The process is thus virtually continuous, the coils of wire being kept out of contact with air from the moment of charging into the furnace until they are removed, cool, from the quench tank. The furnace, which is shown in Fig. 11, is rated at 100 k.w., and has an output of 8–9 cwt. per hour.

This firm have also introduced a new type of nitriding furnace which possesses many outstanding advantages, resulting from the fixture of the work-containers, the furnace being arranged to be located at will over any one of a number of such containers. A circulating fan can be installed in each container, which ensures a uniform distribution of temperature throughout the charge and a proper distribution of "live" ammonia. This ensures contact being made with all the work, and permits of charging the containers to their full capacity without fear of variations in depth of case in different parts of the charge. This type of furnace is illustrated in Fig. 12.

A furnace recently installed at the Vickers works of the English Steel Corporation, Ltd., represents progress in the application of electric energy to spring plate tempering practice. The furnace is of the double-ended type, rated at 65 k.w., and has a hearth area 6 ft. × 4 ft. The springs are loaded on an open-work tray, as shown in Fig. 13, and the heating elements are placed behind baffles in the slides of the furnace so that there is no direct radiation of heat on to the work.

Two centrifugal fans are located below the hearth of the furnace and are connected by ducts with the heating-element spaces. Air is circulated rapidly over the heating elements and through the charge, and heat is thereby transferred to the latter with exceptional uniformity and rapidity. This system is a patented feature.

A range of "Birlec" and Wild-Barfield vertical low-temperature furnaces employing forced air circulation has been introduced to deal with a wide variety of processes. The principle on which these furnaces operate depends on the transfer of heat from the elements to the work by the rapid circulation of air. To this end the heating elements are enclosed in an annular chamber surrounding the cylindrical work-container. A direct-driven centrifugal fan at the bottom of the furnace chamber drives air over the elements and draws it down, with absolute uniformity.

The charge is lowered into the furnace and an easily operated swinging lid covers the opening, being interconnected with a switch which stops the fan and isolates the elements during the process of loading and unloading. An important feature of these equipments is a patented charge progress recorder, an instrument which, besides accurately controlling the furnace temperature, gives a record showing the progress of the treatment. This record informs the operator when the charge is heated through and eliminates waste of time through unduly long heating, besides giving a valuable permanent record of the treatment of each batch of material.

[2] METALLURGIA, September and October, 1931.
[3] *Stahl und Eisen*, vol. 51, No. 17, 513-520.

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METALLURGIA

THE BRITISH JOURNAL OF METALS.

Brighter Trade Prospects and Wise Spending.

THERE is little encouragement in the Board of Trade returns for February, but in view of the condition of world trade, it is gratifying to note that there was no vital decline in the export trade. It is true that exports show an improvement on January, but this is a normal feature of overseas trade at the beginning of the year, and is not sufficient to justify a deduction that trade is reviving. Actually, in comparison with the same period last year, exports show a reduction of £3,063,206; this, however, is offset to some extent by a reduction in imports of £21,098,653, which has now become a normal feature of these returns and indicates quite clearly that the early effect of tariffs, in curtailing imports of manufactured goods, continues. The purchases of foreign manufactured goods last month were just about half the value of those purchased in February last year. Of the exports, it is noteworthy how dependent this country is on its manufacturing industries; goods wholly or mainly manufactured in Great Britain amounted to £21,441,624 out of a total of £27,927,687.

Although the figures do not show any material improvement, trade prospects are brighter than for some time past. This is due in a large measure to the satisfactory work accomplished at the British Industries Fair. Reports indicate that the business done was more promising than was the case last year. Orders were not of an unusual magnitude, but there was a substantial increase in their number, and, judging by definite inquiries, the prospects of trade are distinctly promising. Several other factors, however, have had an influence in creating this brighter outlook, not the least of which is the reorganisation that has been effected in various industries and the improved production facilities resulting. This was amplified in regard to the iron and steel industries by several speakers at the recent annual dinner of the National Federation of Iron and Steel Manufacturers. In their great industry, said the President, Mr. E. J. George, they were not lying down meekly under the imputation of inadequacy or inefficiency, nor were they lying supine and indifferent under the great economic difficulties through which they were passing.

It will be remembered that one of the main values of tariff was associated with reorganisation, the object being to afford industries the opportunity of putting themselves in order on lines best adapted to this country and the diversified nature of the demands which have to be met. In regard to the iron and steel industry, one of the industries of vital importance, a National Reorganisation Committee was appointed, and referring to this Committee, Mr. Charles Mitchell, its chairman, said that no individual industrial concern can be prosperous if the remainder are bankrupt, any more than an industry can be prosperous in a bankrupt community, and therefore it is fully realised that the prosperity of the individual in this industry is dependent upon the prosperity of the industry as a whole. To secure this, the Committee has been working with a substantial measure of success during the last six months, and he looks forward with confidence to a successful outcome of the efforts.

Much reorganisation has already been accomplished, and the impressive progress made is having its effect on trade. To-day signs are not wanting that trade has at last turned. Demands in this country are widening, business is increasing with the Dominions, prospects of more trade in India are improving, and there is a distinct possibility of a revival in South America's demand for steels of various kinds. Market reports are becoming more cheerful, indicating that the position is improving. The shipbuilding industry has received a well-deserved impetus and is rising from its deepest depression. More orders for merchant vessels have been placed since Christmas than during the previous ten months; work has just recently commenced on the 1931 Naval programme, and contracts for vessels in the 1932 programme are being placed. Big contracts will also be placed shortly in connection with the steel works development at Corby.

But while this brighter outlook is noteworthy, will it restore that degree of confidence necessary to attract capital to industry? Much restorative work still requires to be done; new plants and equipment are needed in many industries, and by responsible firms. It is during a time of slackness, when cheap money is available, that reorganisation should be effected. The time is surely ripe for the encouragement of expenditure on sound enterprises, and the abandonment of restrictions on new capital issues. There is an abundance of idle money and a huge body of unemployed workers, and it requires little imagination to appreciate that these can be used to better advantage than they are at present.

The desire for economy has been taken up too literally. A campaign on wise spending would have been more to the point. Unnecessary restriction, which has been accepted for economy, simply increases the ranks of the unemployed. After all, money is valueless unless it is performing its function—that is, acting as a medium of exchange for goods, property, or services, which are the real wealth. If it is not kept in circulation, goods are not being exchanged, and people who make the goods are thrown out of work. Thus, idle money results in idle people. But we are told that there probably never was a time in the history of Great Britain when prices were so low, when goods, material, and labour could be bought so cheaply. This, then, is surely the time for wise and courageous expenditure.

The long trade depression has shaken the confidence of investors, and it is a slow and difficult undertaking to restore this confidence in industry, but when it is recovered it will do much to bring about a revival. It is true that international trade is seriously curtailed by the unprecedented use of prohibition, quotas, and high tariffs, and that any real solution to these must be of an international character, yet advantage should be taken of the improved outlook to prepare for improved world conditions.

There is a tendency to wait for whatever may result from the World Economic Conference, but in view of conditions in America no early meeting can be expected. In any case, when it does begin, it is bound to be prolonged. There is pressing need for action now, and everyone can

assist in making the brighter trade prospects a reality, and even though a complete return to normal prosperity is not possible until some formula has been thrashed out that will restore world confidence, there are sufficient indications that much can be done in a national spirit to assist in realising the prospects. It is of interest to note that the Government are taking action, and the Minister of Labour has invited representatives of the employers and trades unions to discuss with him practical methods by which workers may be absorbed into industry. The time is now ripe for those many necessary schemes which should be put into operation now that conditions are favourable, and the orders resulting would give an impetus to industry and promote at least a partial recovery.

Shipping Optimism.

THE general depression in overseas trade during last year has had its effect on shipping, and it is not surprising that the annual report of the Chamber of Shipping makes uncheerful reading. It indicates declining freights and scarcity of cargoes. Shipping depends almost exclusively on world trade, and with the highly organised systems in operation designed to prevent trade it is bound to suffer. These systems, together with depressing world conditions, caused world trade to fall in value about 42% between 1929 and 1931, and a further drop of 20% has been experienced in 1932.

Despite the somewhat doleful report, it is satisfactory to note that British ships still carry about 99% of our coasting trade, about 94% of the trade between Britain and other parts of the Empire, 90% between all parts of the Empire, and 60% of the trade between the Empire and foreign countries. It is noteworthy, however, that there is a fall in the carrying trade between foreign countries, from 30% in 1913 to 25% in 1929, the last year during normal trade. The fall will undoubtedly have been greater since 1929, due, in a measure, to the policy adopted by foreign governments in granting subsidies in support of their own shipping, and the tendency to build and run ships for political rather than commercial reasons.

This report deals with the past, and gives no indication of the lively interest in shipping that has been experienced so far this year. There has been considerable activity in the majority of the ports which have had laid-up tonnage, and repair yards, particularly on the Clyde and Tyne, are having a busy time in preparing some of these idle ships to re-enter service. Considerable movement has taken place on the Clyde, for instance, where the laid-up tonnage represented over 400,000 tons gross. This has been materially reduced since the new year.

In addition, a number of features indicate a revival in shipbuilding which is evidence of returning confidence in the prospects of improved trading. This view is supported by Mr. Robert Strachan, a director of the Fairfield Shipbuilding and Engineering Co., Ltd., at a recent meeting in Glasgow, when he said that the demand for new merchant vessels has shown signs of awakening, and once shipowners realise the saving in running costs now obtainable from the modern cargo boat as compared with vessels at present in service or laid up awaiting better times, the shipbuilding industry and every other industry allied to it will come into their own.

Much of the laid-up tonnage is unlikely to be capable of competing successfully with more modern vessels even after considerable repairs have been effected, and if orders for new vessels continue to be placed at a rate comparable with those placed since the new year, both employers and employees in the shipbuilding centres will be relieved of much anxiety. Without being too optimistic, there are definite indications of a revival in shipbuilding, and this can only be due to the expectation of improving world trade.

FORTHCOMING MEETINGS.

THE INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.

Mar. 28. "Refrigerated Holds and the Carriage of Foodstuffs," by A. J. M. Smith, M.A., Ph.D.

April 11. Annual General Meeting. Paper to be announced later.

THE INSTITUTE OF METALS.

BIRMINGHAM SECTION.

Mar. 16. "Metals in the Electrical Industries," by C. J. Smithells, M.C., D.Sc.

LONDON SECTION.

Mar. 16. "Recent Developments in Bearing Metals," by A. J. Murphy, M.Sc.

April 13. Annual General Meeting and open discussion.

SHEFFIELD SECTION.

Mar. 17. Discussion on "Annealing." To be opened by E. A. Smith, A.R.S.M.

THE INSTITUTE OF BRITISH FOUNDRYMEN.

BIRMINGHAM AND COVENTRY AND WEST MIDLANDS BRANCH.

Mar. 23. "The Welding of Ferrous and Non-Ferrous Metals," by W. C. Freeman.

April 7. Annual General Meeting.

EAST MIDLANDS BRANCH.

Mar. 25. 1. Annual General Meeting.
2. Short Paper Competition on papers and discussion during the session.

LINCOLNSHIRE SECTION.

April 1. "The Sand Slinger in the Foundry," by A. J. S. Shewan and R. Atchison.

LANCASHIRE BRANCH.

April 1. 1. Annual General Meeting.
2. "The making and use of Graphs for Foundry Purposes," by J. S. G. Primrose, A.R.T.C., A.I.M.M.

April 5. Annual General Meeting. (Preston Section.)

April 15. Short Paper Competition. (Junior Section.)

LONDON BRANCH.

April 13. "The Preparation of Moulding Sands," by Hon. J. M. W. North.

MIDDLESBROUGH BRANCH.

April 7. 1. Annual General Meeting.
2. Discussion.
3. Films of Interest.

NEWCASTLE-UPON-TYNE AND DISTRICT BRANCH.

Mar. 25. "The Preparation of Moulding Sands," by J. B. Corrie.

SCOTTISH BRANCH.

Mar. 25. Annual General Meeting.

Mar. 18. "The Sand Question in regard to Light Casting Production," by F. Hudson. (Falkirk Section.)

SHEFFIELD AND DISTRICT BRANCH.

Mar. 17. Paper by Professor J. H. Andrew, D.Sc.

WEST RIDING OF YORKSHIRE BRANCH.

April 1. "Grey Iron Castings," by F. K. Neath and F. Poole.

THE INSTITUTION OF WELDING ENGINEERS.

BIRMINGHAM.

Mar. 24. "Design and Manufacture of Welded Steel Fabrications," by H. W. Hawkins.

MANCHESTER.

Mar. 22. "Relationship and Application of Various Welding Methods," by P. L. Roberts.

THE INSTITUTION OF PRODUCTION ENGINEERS.

BIRMINGHAM SECTION.

Mar. 16. Grand Hotel, 7 p.m. Paper and discussion.

COVENTRY SECTION.

April 6. Paper and discussion.

GLASGOW SECTION.

Mar. 17. "Works Costing Relative to Production," by W. McFarlane, Esq.

LONDON SECTION.

April 8. Four Short Papers by B. C. Jenkins, E. J. H. Jones (Member), L. Page (Member), and J. R. Standring: "The Manufacture of a Selected Component."

LUTON, BEDFORD, AND DISTRICT SECTION.

April 13. "Modern Heat-treatment of Commercial Products," by Shipley N. Brayshaw, Esq.

MANCHESTER SECTION.

April 4. "The Control of Factory Production," by T. G. Heckels, Esq.

Correspondence

"Patented" Steel Wire.

The Editor, METALLURGIA.

Sir,—Your special correspondent quotes Mr. Bedson as his authority on the origin of "Patenting." I regret not having read Mr. Bedson's paper, but note the extract by your correspondent, in which he states: "I believe it is to Mr. Horsfall in 1854 that the credit of first attempting to *harden and temper* cast-steel wire is due."

What attempts Horsfall made in the direction of hardening and tempering I am unable to say, but have always understood the method for which patents were obtained was the metal bath process of "negative quenching," and which, your correspondent agrees, is the process which produces a complete sorbitic structure.

Bucknall Smith, in his treatise on wire, published in 1891, attributes the invention to James Horsfall of Birmingham, and gives the date as 1854. The terms "Patent Steel" and "Patenting Process" suggest an association with a patented invention, but it is doubtful whether the author was aware actual patents existed.

Before me as I write are two Royal Letter Patents granted to James Horsfall, the one dated 1854 for "Music and Piano Wire," the other taken out in 1856 in connection with "Rope Wire," and a third patent in the joint names of Webster and Horsfall for an improvement in the manufacture of steel wire, dated 1858.

In these days one sees no references or claims made in respect of patents granted for steel wire, and it is reasonable to suppose these three patents are unique, the first of their kind, and from them the term "patenting" originated. If this is so, they are of historical importance to the wire industry. Should your correspondent be interested to inspect the documents, I shall be pleased to make arrangements for his doing so.

It may be of interest to mention that the three principal classifications under which carbon steel wire is made and sold all over the world, "Music," "Patent," and "Plough" were originated and introduced by Webster and Horsfall, the word "*Improved*" following the 1858 patent.

The terms "Plough," "Improved," and "Extra" were first employed about 1859/65 to designate wires supplied to John Fowler, of Leeds, in higher tensiles than patent steel, and were used by him in the manufacture of his ploughing ropes. Originally, these trade terms were prefixed by the word "Agricultural," and it is only within the last forty years that this prefix has been dropped.

The Atlantic cables, for which Webster and Horsfall made the "Improved Patented Crucible Cast Steel Wires," were those of 1865 and 1866, both laid by the Great Eastern. These cables were the first commercially successful.

The iron wire cable of 1857, although not a commercial success, pioneered the project and provided experience which made the success of subsequent attempts possible.—Yours faithfully,

February 24, 1933. J. F. LUCKMAN.

The Editor, METALLURGIA.

Sir,—The very interesting communication from Mr. Luckman brings more light to bear on the subject of the naming of the very high-class product introduced by Mr. Horsfall as "Patented" wire; but even the addendum of the term "negative quenching" does not necessarily imply that this is the same structurally as Mr. Bedson's "Patenting wire process of to-day." Whilst negative quenching undoubtedly leaves the high carbon steel in the maximum sorbitic state, and thereby enables much longer holing to be applied than would be possible under any other circumstances without any further treatment, it is usually of small grain size, so that there is another condition which has arisen largely as the outcome of the "bee-hive oven" process, and that is the development of a *large grain size* in addition to the sorbitic state of the carbon present. These two conditions are not synonymous, as we have found a very large proportion of present-day patented wires have not the full 100% patented structure, even although they have been passed through a patenting furnace. Either the furnace has been too short to enable time for the highest possible temperature necessary to not only spread the carbon but also grow the grain size before the cooling effect on emerging has checked it, or the temperature has not been sufficient, with long furnace time, to allow the wire to attain its optimum conditions of carbon spread and grain growth, and thus the product may be only partly, even "semi," patented. The sole means of determining this is, of course, the micro-structure, and only secondarily the resulting physical properties following upon drawing. We note the modification by Mr. Luckman that the steel cable was the first *commercially* successful in the year 1865, in which it differed from the first iron wire cable of 1857.—Yours, etc.,

March 6, 1933. YOUR SPECIAL CORRESPONDENT.
Manchester.

Corrections.

In our brief reference to the honour conferred upon Sir Robert Hadfield by the Russian Academy of Science in the February issue, and error has crept in with regard to the name of the late Russian scientist with whom Sir Robert maintained close terms of friendship. We, of course, referred to the late Professor Demetri Tschernoff, who was for many years a member of the Iron and Steel Institute, and was made an Honorary Vice-President in 1915. It is generally recognised that the Professor, at one time, contributed much to the handling and heat-treatment of steel by introducing scientific methods.

An error also inadvertently occurs in the caption of Fig. 5 on page 120 of the same issue, which illustrates annealing pots, which are in "Chromite."

Sands, Clays and Minerals.

The current issue of *Sands, Clays and Minerals* is not less interesting and informative than previous issues. Special efforts have been made to make this issue particularly attractive, with considerable success, for not only does it contain a large number of articles on a variety of subjects by recognised authorities, but further coloured plates are introduced showing Ceylon sapphires and various types of coal. The articles are somewhat comprehensive, and deal with the examination of minerals in ultra-violet light; mining English china clay; British minerals; sands for asphalt; extraction of minerals from rocks; the decay and restoration of English building stones; Empire gem stones; notes on tantalum and niobium; Tripoli powder; English industrial sands; minerals and magnetism; refractory cements and lutes; a new elutriator; and the origin, composition, and classification of British coals. The issue is certainly full of interest.

This publication is issued quarterly, the subscription rate being 5s. inland; 5s. 6d. Colonial; $1.00 U.S.A. It is published by A. L. Curtis, Westmoor Laboratory, P.O. Box 61, Chatteris, England.

Personal.

A. G. Wickman, Ltd., Coventry, have been appointed sole agents for the British Isles for the new "Orcutt" hydraulic spline shaft grinder manufactured by the Gear Grinding Co., Ltd., Handsworth, Birmingham. In addition they are also handling all other products of this company.

Messrs. Wild-Barfield Electric Furnaces, Ltd., Elecfurn Works, North Road, Holloway, London, N. 7, inform us that Messrs. G. R. Barclay, J. P. D. Coleman, and J. E. Oram, who have held responsible positions in the firm for a number of years, have been elected to the board of the company.

David Brown and Sons (Huddersfield), Ltd., have transferred their London office to Bush House, Aldwych, W.C. 2. The manager is Mr. A. Avison, A.M.I.M.E., formerly chief estimator at the head office.

Forging and Rolling Temperatures of Steels

By J. H. G. Monypenny, F.Inst.P.

High temperatures facilitate operations in forging or rolling, but they also produce grain growth, which reduces the strength of the material heated. It is thus necessary to compromise, but this is complicated by difficulties in dealing with various ranges of steel, and in this and a subsequent article the author discusses suitable temperatures.

THE main object of the forging or rolling of steel is generally the production of an article of some desired shape; in addition, it is usually important that the hot-working operation shall improve the properties of the material, or at least not damage them in any way. Both these conditions need to be considered in selecting the most suitable temperature for a given hot-working operation, and, as a rule, their reactions to temperature variations are opposite. Broadly speaking, the higher the forging or rolling temperature—within limits—the more easily is the operation carried out, and hence the less the wear and tear on the equipment used for the purpose. On the other hand, high temperatures produce grain growth in the material heated, and coarse structures are generally less strong than fine. The selection of hot-working temperatures in specific cases will therefore vary with circumstances, in particular with the relative importance of ease of working and of structural conditions in the finished product. When special steels are in question, the matter may be further complicated by the hot-working properties of the material being less simply related to temperature than was stated above; certain ranges of temperature may need to be avoided owing to their bad effect on the ductility of the steel.

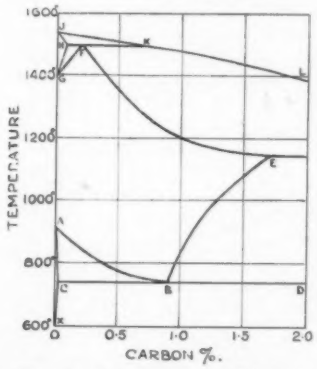


Fig. 1.—Iron-carbon equilibrium diagram.

Hot-working operations on steels may be divided broadly into two categories: (*a*) Those involved in the production from ingots of blooms, billets, slabs, and similar intermediate products; and (*b*) those comprising the production from these intermediate products of bars, forgings, plates, sheets, rod, and similar articles in their final hot-worked form. In operations coming in the first category, ease of production of the bloom, billet, or slab in a form free from cracks, seams, roaks, or other imperfections is of major importance, and structural conditions are not of so great moment, provided, of course, that the material is not burnt or mechanically damaged in the hot-working process. Forging and rolling operations of this type will therefore take place at temperatures giving the greatest plasticity, and, generally speaking, this is the highest safe temperature. In the case of ordinary carbon steels, an estimate of this temperature may be obtained from the iron-carbon equilibrium diagram given in Fig. 1. The line J H F E marks the temperature at which melting commences for any given carbon content, and hence one that must not be reached if burning is to be avoided. What margin should be allowed for safety in practical working will depend on the degree of temperature control which is exercised over the reheating furnaces, but it should certainly not be less than 50° C., and is preferably at least 100° C., particularly with the higher temperatures indicated for the lower carbon steels. Generally speaking, a maximum temperature of 1,250° C. or so is suitable for those of carbon content up to 0·5%; for harder steels the temperature should fall to 1,100°/1,150° C. as the carbon rises to 1·0% and to 1,050°/1,100° at 1·5%.

It goes without saying that success in these, as in all hot-working operations depends almost as much on the article to be worked being heated evenly to the required temperature as on the actual value which this temperature may have. The furnace in which the ingot, bloom, or billet is heated should itself be raised to the desired reheating temperature, and the steel article should be allowed to remain therein until it has been thoroughly heated through. Insufficient heating, leaving the ingot or bloom or other piece with a cold centre or a cold side causes troubles in forging and rolling which are too well known to need further description. The practice of rapidly heating steel in a very hot furnace in such a manner that the outside of a bloom or billet is grossly overheated while the centre is comparatively cold is not prevalent in these days, except in works where output is made a fetish, regardless of quality, and to that end furnace equipment is worked beyond its capacity. It will be assumed in the following paragraphs that reheating furnaces are used in an intelligent manner, and where specific temperatures are mentioned as suitable for certain hot-working operations, it is understood that the steel is to be brought carefully to these temperatures and held there until the whole of the piece to be forged is uniformly heated.

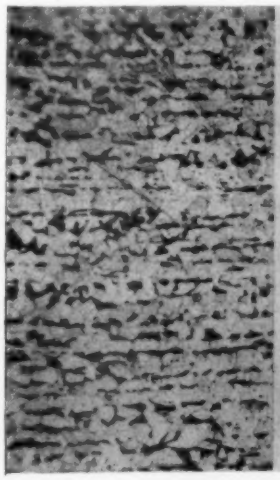


Fig. 2.—Mild steel bar, 1 in. diameter, rolled between 1,000° C. and 850° C. × 100.

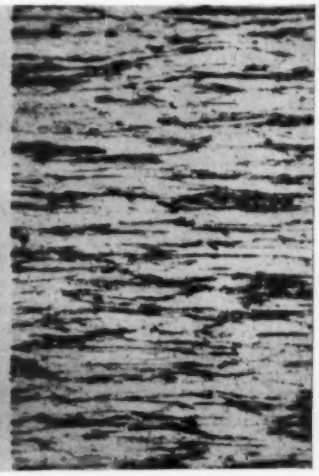


Fig. 3.—Mild steel bar, 1 in. diameter, rolled between 700° and 600° C. × 100.

In those preliminary hot-working operations which have for their object the production of semi-finished material, finishing temperatures are frequently fairly high, and,

generally speaking, they are governed by capacity of the forging or rolling plant rather than by their effect on the structure of the steel. For example, when forging or rolling operations of this type are suspended in order to allow the steel to be reheated, the necessity for this arises more frequently from the stiffness of the steel making a continuation of the work, without reheating, uneconomical, owing to wear and tear on the plant rather than from any damage which might be produced in the steel itself. This, of course, applies to ordinary carbon steels; in the case of alloy steels, conditions are often different, and working has frequently to be stopped until the bloom or slab or other form is again reheated, in order to avoid damage to the steel. Examples of this will be considered later.

In succeeding operations—*i.e.*, those concerned with the production of the final hot-worked form,—temperature conditions have to be studied with more care owing to the much greater importance of structural conditions in the finished article. It will be well, therefore, to consider briefly the effects which hot working at various temperatures produces on the structure of steel.

At forging and rolling heats, steels in general consist of austenite either alone or with excess ferrite or carbide. If the temperature is low enough, the austenite may break up, giving a pearlitic structure. These various structures are common to carbon and alloy steels, and may be typified by those occurring in the former. Hence, in assessing the more or less incompatible factors of structure and ease of working, in the selection of suitable forging or rolling temperatures, it may be useful if carbon steels are considered first. In this case the problem reduces to its simplest form if the hot-working takes place in the range of temperature in which the steels consist solely of austenite. The limits of this range are shown in Fig. 1 by the lines A B E F G. The hotter the steel is heated above A B E the softer and more plastic it becomes, and hence the more easily is it worked. A limit is set, of course, by the melting of the steel, which begins when the temperature reaches J H F E. As the temperature rises over the range included between these two curves, however, grain growth of the austenite takes place with increasing rapidity; heating to a very high temperature, therefore, entails a coarse grain in the steel before forging or rolling commences. These latter operations break up the grain again, but the broken-up fragments immediately start to recrystallise and grow. To what extent the grain size will be reduced by the hot-working operation will depend therefore on the amount and speed of working and the temperature at which work ceases. In order to produce as fine a grain as possible in the austenite, the steel should be worked continuously, down to a temperature as near to A B as possible—that is, if it is intended to work the steel solely while it is in the completely austenitic condition. From this point of view, therefore, the temperature to which steel is heated prior to working will vary with the amount of work to be done, being adjusted so that the finishing temperature is as nearly correct as possible.

Is it necessary, however, to complete forging or rolling operations while the steel is steel completely austenitic? An answer to this question may be sought by considering first what happens when work is continued after the steel has cooled below A B E (Fig. 1). At temperatures between A B and C B, steels with less than 0·9% carbon consist of mixtures of alpha and gamma iron, the latter containing the carbon in solution. Rolling or forging in this temperature range will therefore produce a more or less banded or laminated structure (depending on the shape of the worked article) of these two constituents. Each constituent, however, is still capable of recrystallising, hence the separate bands will consist, as a rule, of more or less equiaxed grains. At still lower temperatures, below C B, the austenite changes to pearlite, and if work be still continued, the banded structure is further intensified. At these low temperatures recrystallisation takes place at increasingly slower rates, but it will occur in the ferrite, if time be allowed, at temperatures down to about 550° C. In the case of the pearlite, which is formed when the temperature falls to C B, forging or rolling tend to break up the lamellæ of carbide which it contains, and the broken fragments, again if time be allowed, will gradually assume a more or less spheroidal form.

Structures laminated in a similar manner will be obtained if the steels are heated initially to some temperature below A B, and rolling or forging then commenced.

Summing up, therefore, steels containing less than 0·9% carbon, which are hot-worked at temperatures above A B, will consist, when work is completed, of equiaxed austenite grains, whose size will depend on the actual finishing temperature and the amount of work received. On subsequent cooling, these grains will split up into equiaxed grains of ferrite and pearlite, which will not be arranged in a markedly banded manner unless the steel itself (*e.g.*, owing to a high content of non-metallic inclusions) is predisposed to banding. On the other hand, working the steel below A B will produce a more or less banded arrangement of ferrite and pearlite, although the grains of which these bands consist may still be equiaxed. The amount of banding or lamination produced will obviously depend on the size of bar or other product which is being worked and the extent to which it is deformed during the period when it possesses a duplex structure, but Figs. 2 and 3 illustrate the structural effects in mild steel bars, 1 in. diameter, rolled from billets 2¼ in. square. In one case rolling commenced at 1,050° C. and was completed at about 850° C. (*i.e.*, the beginning of Ar. 3), the resulting bar having the structure shown in Fig. 2. Fig. 3 represents the result obtained when rolling was commenced at 750°/800° C. and continued down to about 600° C. Obviously, structures of the latter type can only be obtained in small-sized material.

A sequence of events much the same in character, but differing to some extent owing to the hardness and brittleness of cementite as compared with ferrite, occurs in steel containing more than 0·9% carbon. Cementite commences to separate in these steels, during cooling, when the temperature reaches B E (Fig. 1), and, if undisturbed, will form a more or less complete network round the austenite grains. Working the steel during this period breaks up the carbide network to a greater or less extent, the broken-up fragments tending to become more or less rounded (owing to surface tension effects), and to be arranged in bands as the hot-working proceeds. If working be continued below Ac. 1, the pearlite is affected in a similar manner to that in lower carbon steels.

Although from the structural details discussed up to now there would appear to be no reason why forging or rolling should not be continued in ordinary carbon steels down to about 600° C., or even somewhat lower, there are other considerations which may make this very inadvisable. The stiffness of steels increases very noticeably as their temperature falls below about 700° C., and if they are forcibly deformed under unfavourable conditions at these low temperatures they may crack or develop weakness along certain planes. In this respect, one may refer to the relationship between toughness (as measured by a notched-bar impact test) and temperature as shown by the curves in Fig. 4. It will be noted that the toughness value drops rapidly when the temperature falls below 650°-700° C. Above this temperature the notched pieces did not break, they merely bent through an angle of about 150°, and the increasing values obtained as the temperature was reduced from 1,000° to 700° C. or so reflect the gradual increase in strength of the cooling steel. Below 650°-700° C. the test-pieces broke at the notches, instead of bending, and the low toughness values possessed by the steels at these temperatures suggest strongly that hot-working, and particularly that form of it produced by blows, should not generally be continued below 650°-700° C.

When hot-working is continued to these low temperatures, even though they are not lower than the minimum suggested, it is to be expected that the forged or rolled article will no longer be uniform in temperature; contact with rolls or hammer faces is certain to cause local cooling

effects, and the latter will be especially noticeable at sharp corners. In applying the results of Fig. 4, it should be remembered that they apply particularly to these cooler parts; the body of a forging may be well above the critical toughness temperature shown in the diagram, but that fact will not prevent trouble occurring at the cooler edges or corners of the forging if these are forcibly deformed.

The possibility of using forging or rolling temperatures approaching 650°-700° C. will also depend on the size of the finished article and the power available to work it. Generally speaking, the use of finishing temperatures of this order is only possible in small-sized material—not larger than 2 in., or possibly 3 in. For larger sizes, higher temperatures —*e.g.*, 800° or 850° C.—are usually necessary to prevent undue stresses in the forging or rolling plant.

Much also depends on the shape of the forged or rolled part. In the production of rectangular bars, for example, deformation at low temperatures leads to the material being severely deformed along the diagonals of the cross-section, and if this be carried to extremes, fracture may occur in the manner shown in Fig. 5. The actual specimen illustrated here is of a hard heat-resisting alloy, much more prone to develop such cracks than ordinary steel, but even if actual separation does not take place to the extent shown in this illustration, the material may be badly crushed along these diagonal planes, giving rise to minute discontinuities which will cause trouble in subsequent hardening operations. This is particularly the case with tool steels, which, if rolled or forged in this manner, may crack when later they are hardened.

As a contrast the rolling of thin sheets may be mentioned; it is not generally desirable to heat the "scalers" from which these are rolled to temperatures much above about 900° or 950° C., or excessive scaling will probably occur, to the detriment of the surface of the finished sheet, and as such sheets cool very rapidly during rolling, this process is generally continued below even 600° C., no ill effects being thereby produced. The whole matter, however, depends on the amount and character of the deformation at each pass in the rolls or blow of the hammer, and, except in special circumstances where the amount of reduction per pass is small, as in sheet rolling or the final passes of a "hand-rolled" round, it is better to arrange matters so that working is not continued at temperatures below about 700° C.—*i.e.*, the carbon change-point of the steel. This is particularly the case with tool steels having a carbon content above 0·7% or so, which, owing to their hardness, are more likely to crack or to be weakened along planes severely deformed.

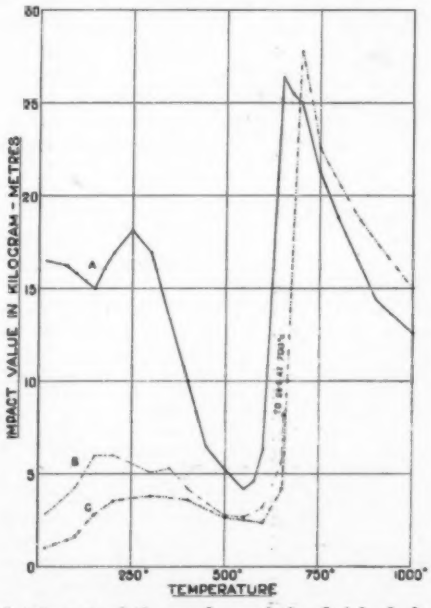


Fig. 4.—Impact values of steels at high temperatures. A, 0·23% carbon; B, 0·47% carbon; C, 0·73% carbon

On the other hand, it is also important that the finishing temperature of high-carbon steels should not greatly exceed their carbon change-point, particularly those steels which contain structurally free cementite. If existing as a network round the pearlite grains, as is the case in such steels when they are cooled freely in the air from above

Fig. 5.—Billet of heat-resisting steel cracked through forging at too low a temperature.

Ar.cm., cementite has a much greater adverse effect on the toughness of steel than when it occurs in more or less globular form. Forging or rolling should therefore be continued on such steels to a temperature as nearly approaching their Ar. 1 change-point as possible, in order that the cementite they contain may be dispersed in small broken-up particles. The necessity for carefully controlling to forging temperatures of these high-carbon steels is known to every tool-smith, and it has this further importance that the effects of overheating on these steels cannot be completely removed by heat-treatment operations, or, at least, only with great difficulty. The belief of the old tool-smith that an overheated high-carbon tool steel could only be restored by further forging applies equally well in these days of scientific heat-treatment. As a result, such steels should rarely be reheated for forging or shaping operations above about 1,000° C., and even so high a temperature as this should not be employed unless sufficient work has to be done on the tool to necessitate the forging operation continuing down to about 700°-750° C. A hardened tool in which the carbide exists as spheroidal particles dispersed through the martensite (as would be produced by forging on the lines mentioned above, followed by hardening in the normal way at 750°-780° C.) is much stronger and tougher than one in which the carbide forms a network, possibly not quite continuous, round the martensite grains.

In the case of steels containing less than 0·9% carbon, which have subsequently to be heat-treated, the necessity for ensuring a low finishing temperature is not so urgent on structural grounds, because a coarse structure can be adequately refined by the heat-treatment which is to follow. At the same time, high forging temperatures are undesirable on other grounds. They produce heavy scale, and even if the latter is removed during hot-working (there is always a possibility that some may be trapped in the steel), the surface underneath is likely to be rough and pitted; in addition, it will probably be heavily decarburised. In these days, when as little as possible is removed from the surface of a bar during machining, it is quite likely that the rough decarburised surface produced on a bar rolled or forged at an unduly high temperature may not "clean up" with the ordinary machining allowances. For these reasons, it is advisable that finishing temperatures should not unduly exceed 750° or 800° C., reheating temperatures (which as a rule should not be higher than 1,150° C.) being adjusted to this end.

When it is intended to use steels of this type in the rolled or forged condition, finishing temperatures should be carefully controlled on structural grounds. Such steels are distinctly less tough and ductile when overheated than when possessing a fine structure; hence, when mechanical properties are of importance, finishing temperatures should not exceed about 700° C. For most purposes for which bars or forgings are used without subsequent heat-treatment the banded structure produced by working below Ar. 3 is of no detriment; on the contrary, it improves the properties of the bar or forging. Where simple shapes—*e.g.*, rolled bars of small size—are concerned, hot-working may quite well be continued to lower values than 700° C., particularly when the carbon content does not exceed 0·5% or so. By this means the impact value of the steel may frequently be quite noticeably improved. It is somewhat dangerous, however, applying the process to steels of very low carbon content, 0·1% or less. If such steel is given a series of slight reductions between about 600° and 700° C., rapid grain growth may occur in the ferrite, in a similar manner to the abnormal grain growth which is produced in material of this type when it is cold-worked to a small amount and then reheated to 700° C. or thereabouts. When possessing such a coarse structure, the material may have an almost unbelievably low impact value, as witness the results on bar B in Table I.:—

TABLE I.

MECHANICAL TESTS ON VERY SOFT STEEL.

C. %. 0·09 .. Si. %. 0·17 .. Mn. %. 0·34 .. S. %. 0·034 .. P. %. 0·025

Bar.	Treatment.	Y.P., %.	M.S., %.	E., %.	R.A., %.	Impact, Ft.-lb.
A	Rolled, 1,000° C.	20·4	25·8	41·0	69·8	91
B	Rolled, 700° C.	23·2	28·4	30·0	60·4	16
C	Bar B, normalised, 900° C.	18·2	24·4	38·0	65·8	92

The bars were 1 in. in diameter, and were rolled from billets about 1½ in. square. The brittleness produced by the low temperature rolling may of course be removed by normalising at a temperature just above Ac. 3, as is shown by the results on Bar C in the table.

The presence of any appreciable amount of pearlite in the steel restricts very markedly the amount of grain growth taking place under these conditions. As a result, abnormal grain growth will probably not be produced in steels containing over about 0·2% carbon, or even 0·15%, especially if their manganese content is 0·5% or more.

It will be noticed that the tensile strength of bar B is somewhat higher than that of bar A. By increasing the amount of work at such temperatures, the tensile strength of mild steels may quite readily be raised four or five, or even more, tons per square inch. Such an increase in strength, however, is not an invariable feature of bars rolled at these temperatures; for example, steels consisting largely of pearlite may be softened to quite an appreciable extent by rolling between about 600° and 700° C., due to the balling-up of the carbide lamellæ in this

TABLE II.

Carbon, % 0·65 .. Silicon, % 0·17 .. Manganese, % 0·87

Treatment.	M.S., %.	E., %.	R.A., %.
Rolled, 700° C.	54·6	24·0	47·2
Rolled, normalised, 830° C.	60·7	17·5	40·0

constituent. A good illustration of this is provided by the tests in Table II., where the bar rolled at 700° C. has a tensile strength some six tons per square inch lower than that of the same bar after normalising at 830° C. Microscopical examination showed that the pearlite in the rolled bar was mostly globular.

Summing up, it may be stated that in forging or rolling operations other than those concerned with the production of intermediate products, such as blooms, billets, and slabs, reheating temperatures should not as a rule exceed about 1,150° C. for mild steels and 1,050° C. for high-carbon steels, and should be adjusted to lower values than these, if necessary, so as to ensure that finishing temperatures do not unduly exceed about 700° C. Still lower finishing temperatures may be used with discretion in special cases, providing the material is not cracked or unduly stressed in the process.

Reference was made earlier to the possibility of some temperature range having to be avoided, during hot-working operations, owing to the material being worked lacking ductility in that range. A very good example of this is provided by the behaviour of the form of commercially pure iron made in the open-hearth furnace and marketed under the trade name "Armco." This material may be forged or rolled readily at temperatures above about 900° C. and below about 800° C., but between these two temperatures it is extremely redshort. The onset of this redshortness takes place quite sharply, and it also disappears abruptly when the material has cooled down to 800° C. The cause of this peculiar behaviour appears to be connected with the separation, between these temperature limits, of a constituent having a eutectic type of structure, and which may be found in samples heated to 1,000° C., or over, cooled to between 800° and 900° C., and then rapidly quenched. Samples quenched above or below this temperature range possess a normal structure of ferrite. Another peculiarity is that the redshortness is only produced between 800° and 900° C. when the material is cooling through this range after being heated to higher temperatures. If heated directly to 850° C., for example, no evidence of redshortness is observed.

The factors which have been briefly discussed in this article apply not only to carbon steels, but also to alloy steels, though with modifications as to actual temperatures. The latter, however, may be deduced from the general principles discussed in relation to carbon steels, and it is proposed to deal with this aspect of the matter in the next part of the article.

The Iron and Steel Institute.

The Council of the Iron and Steel Institute announces that Mr. Kenneth Headlam-Morley has been appointed Secretary in succession to Mr. G. C. Lloyd, who will retire shortly after an association of about 30 years with the Institute. Mr. Headlam-Morley will take up his duties about the end of June of the current year.

Mr. Kenneth Headlam-Morley is the only son of the late Sir J. W. Headlam-Morley, the former Historical Adviser to the Foreign Office. He was educated at Eton and Oxford, where he was a scholar at New College, and took honours degrees in Lit. Hum. and History. Mr. Headlam-Morley joined the staff of Dorman Long and Co., Ltd., in 1925; after a technical training in their iron and steel works at Middlesbrough he has been occupied in their Secretarial, Managing Director's, and By-Products Departments. He has travelled extensively in France and Germany, and is well acquainted with the Iron and Steel Industry of Western Europe.

The Council of the Institute of Metals has accepted an invitation from the Committee of the Institute's Birmingham Local Section to hold the Silver Jubilee meeting of the Institute in Birmingham from Monday, September 18, to Thursday, September 21. It would appear to be particularly appropriate for this notable anniversary to be celebrated in Birmingham, as it was in that city that the Institute of Metals had its first office (in the Metallurgical Museum of the University), and held its first autumn meeting in 1908.

On Wednesday, May 10, Monsieur Albert M. Portevin, the distinguished French engineer and President of the Societe des Ingenieurs Civils de France, will deliver the twenty-third annual May lecture to the Institute of Metals. The subject of M. Portevin's discourse will be "Quenching and Tempering Phenomena in Alloys."

Improvements in Rolling Mill Design

By Alfred F. Dixon

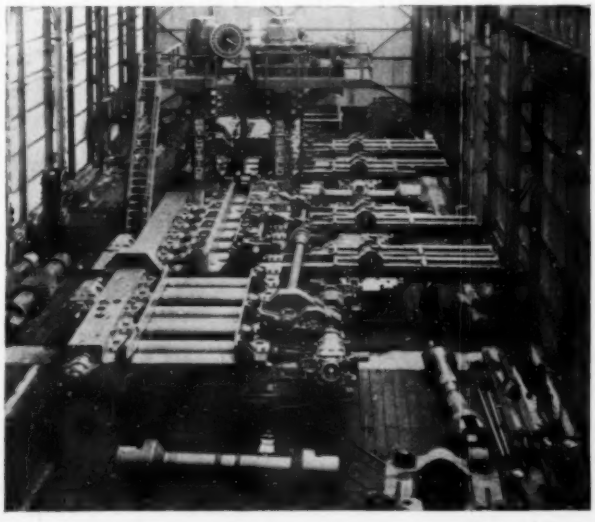
Increased accuracy and improved quality of product are appreciated in the rolling mill and developments in plant and equipment, as well as improved technique, are responsible for much of the progress achieved during recent years. The author discusses some of these improvements.

DURING the last few years considerable improvements have taken place in the design and construction of all classes of rolling mills for the hot-rolling of steel and non-ferrous metals. These improvements in the design of the larger class of mill, such as blooming, cogging, and roughing mills, have not only considerably increased the outputs in tons per hour of slabs, blooms and billets produced, but at the same time have reduced the cost of production, cut down maintenance charges, and increased the overall efficiency of the plant.

The improvements in design may be briefly summarised as follows :—

1. Electric driving of the mill and auxiliary equipment.
2. Stronger section of roll housing posts so as to eliminate spring, and bracing both housings strongly together so that they form one rigid unit.
3. Mounting the rolls in water-cooled chocks lined with anti-friction white metal, the roll necks being lubricated automatically from a pressure grease pump.
4. Adjustment of the rolls endwise by means of hinged clamp plates.
5. Automatic electric control for adjusting the draft of the rolls.
6. Hydraulic or electrically operated quick roll-changing mechanism.
7. Rigid mounting of the driving mill pinions in totally enclosed housings, with gravity or pressure oil feed to the pinion teeth and bearings.
8. Universal spindle drive from the pinions to the rolls.
9. Electrically driven side-guard manipulators each side of the mill.

Fig. 1.—35 in. reversing roughing mill.



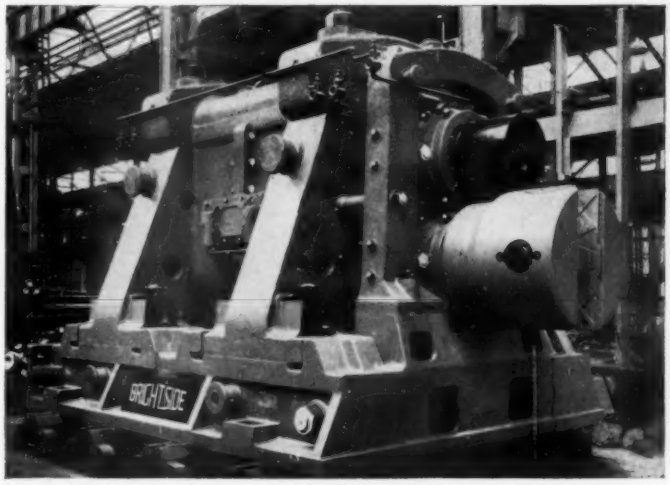


Fig. 2.—Arrangement for pinion housing for 35 in. reversing roughing mill.

10. Stronger construction of live roller tables adjacent to the mill on each side. Driving mitre gears totally enclosed, running in an oilbath, and grease-gun lubrication to roller necks.

Fig. 1 shows the general construction of a modern electrically driven 35-in. reversing roughing mill. The roll housings are of the built-up type, and are strongly braced together at the top and bottom by heavy castings, so as to form one complete unit, the whole being rigidly bolted down to the mill bedplate.

The rolls are mounted in chocks of the enclosed type, arranged for water cooling, and having compound wearing surfaces of white metal and phosphor bronze. The roll necks are lubricated under pressure from a mechanically operated grease lubricator, the chocks also, where in contact with the housing wearing plates, being lubricated from the same source. For changing the rolls quickly, a hydraulically operated roll-changing rig is provided which enables the rolls and chocks to be removed axially through the outer window of the housing. The screw-down mechanism is of the bevel-gear type, driven by two electric motors, the latter being connected through slipping clutches to the pinion-shafts arranged on each side of the main driving spur-wheel.

The arrangement of the totally enclosed pinion housing is shown in Fig. 2. The pinions are of forged steel, having machine-cut double helical teeth, the pinion teeth and bearings being lubricated by gravity from a centralised oil system. The botton pinion is directly coupled to the main driving motor through a flexible slap-type coupling. The pinion housing is rigidly bolted down to a bedplate, the latter being connected to the roll housing bedplate, so that both rolls and pinions are in true alignment with one another. The rolls are driven from the pinions through universal coupling spindles, the latter being hydraulically balanced. Electrically driven side-guard manipulators are arranged each side of the mill. These are driven from one side of the mill by racks and pinions, and totally

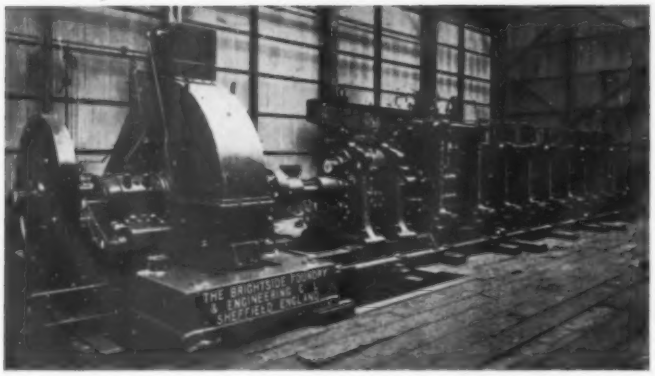


Fig. 3.—High-speed flywheel unit and 12 in. mill.

enclosed reduction gear-sets. On the ingoing side of the mill electrically driven tilting fingers are provided on the near side manipulator head.

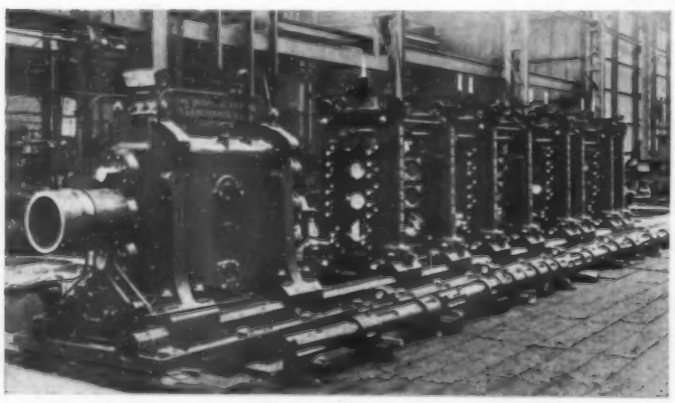
The live roller tables on each side of the mill are of strong construction, rigidly braced together in order to withstand the heavy shocks imposed on the live rollers due to the passage of the ingot through the mill rolls. The "live" rollers are solid forgings, driven by electric reversing motors through totally enclosed machine-cut mitre gears, the latter dipping in an oilbath provided in the roller frames. The thrust on the lineshaft due to the drive is taken on a ball bearing located at the end of the roller frames. The rest bars and guides are so designed that they can be easily taken out as one unit when roll changing.

In the smaller classes of rolling mills used for the production of hot steel rounds, squares, hexagons, flats, and other small sections, having rolls 10 in. to 20 in. centres, the improvements in design and construction have been principally confined to the following :—

1. Electrically driving the mill through a high-speed flywheel set and totally enclosed machine-cut reduction gears.
2. Totally enclosed machine-cut pinions, with gravity feed lubrication to the pinion teeth and bearings.
3. Mounting the rolls and pinions in roller bearings or special mixture metal steps to reduce friction.
4. Automatic pressure grease lubrication to the roll necks.
5. Adjustment of the rolls endwise to take the thrust.
6. Fitting the roll housing with loose caps to facilitate roll changing.

These improvements have considerably reduced the friction of the mill, speeded-up production, and enabled the mill to facilitate production to very small tolerances which are now called for on hot-rolled products. The improved methods of lubrication have increased the life of the wearing parts and reduced maintenance charges.

Fig. 4.—12 in. Three-high Mill.



The mounting of the rolls and pinions in roller bearings has received considerable attention in the last few years, and developments on these lines may be expected in the near future. Roller bearings are now being extensively used in reduction-gear sets and live roller tables, the use of which effects considerable saving in driving power.

Fig. 3 shows a 12-in. mill for rolling hollow drill steel, also rounds, squares, and hexagon steel bars. This mill comprises five stands of roll housings and one stand of totally enclosed pinion housings, all rigidly bolted down to a strong bedplate. It is driven by a 350-h.p. motor, having a synchronous speed of 585 r.p.m., the motor being connected by a flexible coupling to the pinion shaft of a single reduction-gear set, having a ratio of 5/85 to 1. On the same shaft are two overhung flywheels, 6 ft. diameter, each weighing 2 tons.

The pinions and driving-shaft bearings are lubricated by gravity from a tank carried on the top of the casing which encloses the gearing, the oil being circulated by a rotary pump from a tank fixed below the floor level. The gears are self-lubricated from an oil sump provided in the gear-case. With this arrangement a heavy oil is used for lubricating the teeth of the gears, and a light oil for the bearings.

The roll housing chocks are set up endwise by setting-up clamps ; these can be moved outwards clear of the housing windows when roll changing, enabling the chocks to be easily removed. The top rolls are spring-balanced, and the bottom rolls provided with wedge adjustment.

A 12½ in. to 10½ in. three-high mill for rolling steel sash-bar sections is shown at Fig. 4. It is also suitable for the production of merchant bars, flats, and varied sections. This mill comprises four stands of roll housings and one stand of totally enclosed pinion housings, mounted on a strong bedplate. In addition, there are six pairs of spare roll housings, each pair being mounted on its own bedplate. These spare housings are set up with rolls, cramp-bars, and guides, so that when necessary to change over from rolling one type of section in the mill to another, one or two pairs of housings are lifted off the mill bedplate as a complete unit by the overhead crane and replaced by one or two of the spare sets. This arrangement saves the time which would otherwise be lost in roll changing and setting up the cramp-bars and guides, and enables the mill to work continuously on full production.

This mill is driven from an electric motor 450 h.p. normal, 900 h.p. momentary maximum, having a speed of 350/700 r.p.m., reducing through a totally enclosed single-reduction gear set to 200/400 r.p.m. on the mill. The driving-shaft of the gear unit is connected to the centre mill pinion, with an Ortmann type coupling. The mill pinion teeth and bearings are lubricated by gravity, the oil being circulated by two rotary oil pumps, one supplying a heavy oil to the pinion teeth, and the other a lighter oil to the bearings.

In this mill the chocks are held in position in the roll housings by mild-steel plates bolted to the housings, the chocks being set up endwise by setscrews screwed into the plates. Slot holes are provided in the plates so that they can be moved outwards clear of the housing windows, to allow the chocks to be withdrawn when roll-changing. The top rolls are spring-balanced, and wedge adjustment provided for setting the bottom rolls.

The 12-in. three-high mill shown in Fig. 5 is driven through a totally enclosed pinion housing from a heavy rope flywheel keyed direct on the mill driving-shaft, the latter engaging with the middle mill pinion through a cast-steel jaw-clutch. The roll housings are designed for quick roll-changing, being fitted with loose caps, which are held down in position by four heavy cast-steel bridles and forged-steel cotters. The bridles are pivoted from the stay-bolts which tie the housings together. The housing caps are made in halves,

and are rigidly bolted together at the centre. This design of housing saves considerable time in mills where there is a large amount of roll-changing, as it is only necessary to withdraw the cotters, swing the bridles outwards until clear of the housing caps, and then lift the caps off as one unit. The rolls and chocks are then easily taken out and replaced with another set of rolls. The housings are fitted with bottom screw adjustment for raising and lowering the bottom roll. This is operated from one side of the housing by means of a hand lever and vertical shaft through a machine-cut pinion and spur-wheel carried in a gearcase fixed to the underside of the housing. Cast-iron indicator drums are fixed to the top housing screws, with necessary pointers for indicating the setting of the rolls.

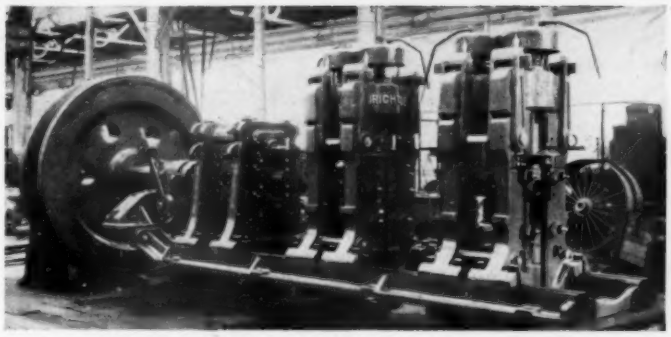


Fig. 5.—12 in. Three-high mill with loose top caps.

Non-Ferrous Mills.

Recent developments in mills for the hot rolling of non-ferrous metals have resulted in plant being installed embodying mechanical improvements which have considerably increased production, reduced labour and maintenance charges, and at the same time enable better products to be rolled more efficiently and expeditiously. These plants are now being laid out on similar lines to those in a modern steelworks, the mills and auxiliary equipment, however, being of lighter construction, as the production is chiefly confined to the rolling of small ingots into sheet bar and slabs down to strip.

A plant on these lines has lately been installed for the hot rolling of nickel and nickel alloys, comprising an 18 in. × 21 in. Universal three-high mill, and a 26 in. × 52 in. three-high Lauth mill, complete with driving unit, live roller tables, tilting tables, shears, and coiler. The Universal mill is designed to roll sheet-bars 8 in. to 10 in. in width, and of all thicknesses from cogged slabs 4 in. thick, weighing up to 1,120 lb. Normally, it rolls 8 in. wide sheet-bars from 8 in. × 4 in. cogged slabs weighing 560 lb. In addition, it will roll small quantities of rectangular and square bars from 8 in. × 8 in. cogged blooms. Besides the foregoing products, the mill produces strip 4 in. to 15 in. wide, $\frac{1}{8}$ in. to $\frac{3}{8}$ in. thick, from previously rolled slabs of suitable initial thickness. The maximum length of strip which is rolled is 65 ft. to 70 ft.

The Lauth mill is designed to roll sheets up to 48 in. wide from sheet-bars 8 in. wide and upwards. It is also capable of occasionally rolling light plates from slabs up to $1\frac{1}{2}$ in. thick, the maximum length rolled being about 12 ft.

The Universal and Lauth mills are arranged on either side of a totally enclosed gear-reduction unit, the latter being driven by a single 750-h.p. motor, having a synchronous speed of 585 r.p.m. The gear unit is designed to transmit a normal h.p. of 1,500, with peak load up to 4,500 h.p. The gearing ratio is 9·6 to 1, which gives a speed on the driving-shaft of 61 r.p.m. If the production in the future is such as to call for further h.p. a duplicate motor running in parallel with the present motor will be added at the other end of the driving pinion shaft. An arrangement of the gear unit is shown in Fig. 6. The main driving shaft of the gear unit is connected to the central pinion of each mill with a hydraulically-operated Ortmann type coupling, supported in a white metal-lined bearing, totally enclosed and continuously lubricated. This arrangement allows both mills to be worked together, or if necessary either one mill or the other, as either coupling can be thrown out of engagement in a few minutes.

The gear unit is of the double reduction-gear type, having machine-cut teeth throughout. On each end of the pinion-shaft is mounted an overhung flywheel, 7 ft. 6 in. diameter, weighing 6 tons. The gearing and shafts are mounted in a heavy bedplate, the pedestals being cast solid with same. The unit is totally enclosed, and the gears and bearings are lubricated from a central automatic gravity return system, which also serves the disengaging couplings, the pinion housing of each mill, screwdown gear mechanism, and vertical roll drive for the Universal mill. The oil in this system is circulated by a pair of rotary pumps, one driven from the gear unit and the other from an independent motor, the latter being a standby.

A general view of the Universal mill is shown in Fig. 7, in which the pinions are of high carbon forged steel, having machine-cut double helical teeth, and are mounted in chocks lined with high-grade anti-friction white metal. The chocks are carried in a totally enclosed pinion housing, which is bolted down directly on the foundation and is connected to the bedframe of the gear-reduction unit through the Ortmann coupling bedframe and on the other side to the mill bedplates, thus forming a self-contained unit. The drive from the gear unit is by the central pinion, the other end of each pinion being connected to each of the horizontal mill rolls by ball-ended coupling spindles and ordinary boxes. The vertical rolls are driven through mitre gears contained in an enclosure cast with the roll housings; the driving-shaft is connected by a flexible coupling spindle to suitable gearing contained in the pinion housing. The intermediate gear between the top mill pinion and pinion on the spindle driving-shaft is arranged as a free-wheel drive to permit the slipping of the vertical rolls when the piece has been gripped by the horizontal rolls, thus relieving the drive of undue strain.

The roll housings are of heavy section, having the enclosures for the vertical roll guides cast in one with the housings; this forms a very rigid mounting, and allows the centre of the vertical rolls to be as close as possible to the horizontal rolls. The horizontal rolls are 18 in. diameter × 21 in. long, and the vertical rolls 14 in. diameter. The rolling speed of the mill at the synchronous speed of the main driving motor is 300 ft. per min. The main rolls are mounted in chocks of the enclosed type, arranged for water-cooling, and having compound wearing surfaces of white metal and phosphor bronze. The lubrication of the roll necks, together with that of the chocks in the housing

Fig 6.—Totally enclosed double-reduction gear unit.

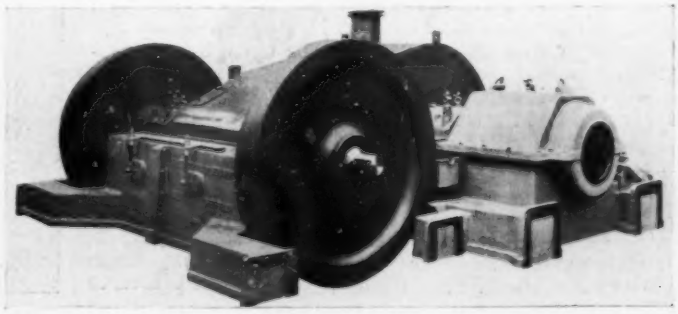


Fig. 7.—18 in. × 21 in. Three-high universal mill.

windows and vertical roll guides, is effected under pressure from a mechanically driven grease pump. The screwdown gear is of the two-motor type. Each motor is connected to the worm-gear, operating one screw by a train of reduction gearing, but the two sets of gearing can be connected at will by means of an electromagnetic coupling, so that either screw or both may be operated as desired.

To facilitate the changing of the rolls for re-grinding, a hydraulically-operated roll-changing rig has been provided. This enables the rolls and chocks to be removed axially through the window of the outer roll housing very quickly. On either side of the roll housing are the hydraulically-operated tilting tables arranged with hydro-pneumatic balancing, which entirely eliminates all shocks and jar. The movement for the raising and lowering of the middle roll is also derived from the operating mechanism of the tilting tables. All the rollers in each roller table are mounted in roller bearings, and the gearing is totally enclosed, running in an oilbath.

Beyond the tilting tables the roller gear is extended on the entry side to the discharge from the reheating furnace, and further through a pinch roll unit to a subterranean strip chute running under the road, and on the delivery side to an electrically driven cropping and cutting-up shear. Beyond the latter is located a stacking pocket for receiving the sheet-bar, which is cut to a length of 5 ft. This pocket is displaced in a transverse direction hydraulically. When sheet-bar is being rolled the pocket is positioned directly behind the shear, where it remains until full, when it is taversed to one side to permit of discharging by a 1-ton floor-controlled crane. When strip is being produced, the latter is moved into its discharging position, which simultaneously brings up a short length of driven roller gear into line with the approach table to the shear, to carry the strip into the coiler. The shear is of the up-cutting type, having a blade load of 90 tons. A hand-operated stop and measuring device to deal with lengths up to 5-ft. is provided.

The coiler is located below the run-out table. The strip is diverted into the coiler by a deflecting switch, and passes through pinch rolls into the circular spool surrounded by the six driven rollers. It is here coiled up, the rollers opening out as the coil increases in size. When the strip is coiled the rollers are opened out still further against the resistance of the balance weight by a hydraulic cylinder, when the coil drops on to a central stem and hangs there until a hydraulically-operated stripper ejects the coil on to a receiving stand, from which batches of coils are removed by the 1-ton floor crane. The mill is served by an oil-fired continuous re-heating furnace.

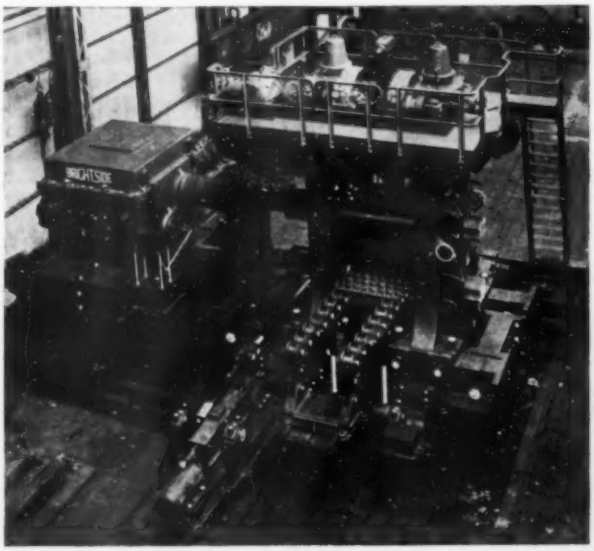
A general view of the Lauth three-high sheet mill is shown in Fig. 8. The top and bottom rolls have a diameter of 26 in., and the middle roll 16 in., the barrels of the rolls being 52 in. long. The normal speed of the rolls is 37 r.p.m., giving a rolling speed of 250 ft. per min. The general characteristic design of the mill is similar to that of the Universal mill. The screwdown gear is operated by a single 30-h.p. motor through single reduction gears and worm gearing, each screw being operated individually or collectively by means of electromagnetic clutches. On each side of the mill are hydraulically operated tilting tables equipped with dead rollers. The movement of the middle roll up and down is worked as in the Universal mill. The heating of the sheet-bar for this mill is carried out in a special semi-continuous electric furnace.

The general arrangement of a 22 in. × 40 in. hot mill for rolling aluminium ingots 4¾ in. thick × 10 in. wide, 30 in. long, down to strip 5 to 7 mm. thick, is shown in Fig. 10. This mill is driven by a high-speed flywheel set by a 150 h.p. motor running at 725 r.p.m., and reducing through a totally enclosed double reduction-gear unit to 40 r.p.m. on the mill. The pinion housing is totally enclosed and rigidly bolted to the extension of the mill bedplate. Both the gear unit and pinion housing are lubricated on the gravity oil system, the oil being circulated by a rotary oil pump. The housing chocks are white-metal lined, the roll necks being lubricated under pressure from a mechanically operated grease lubricator. The top roll is electrically balanced. The screwdown gear is operated through a single reduction gear, and worms and worm-wheels by a 10 h.p. motor. The electric control gear for the screwdown motor is so arranged that the draft on the rolls is set automatically for each pass by the operator pressing a button. On the outgoing side of the mill is an electrically operated tilting table fitted with dead rollers, so arranged that when the material has passed through the rolls it is automatically returned over the rolls to the operator on the ingoing side.

There are two cold rolling mills working in conjunction with this mill. One mill reduces the strip after it leaves the hot mill from 7 mm. thick to 2 mm. thick, and the other reduces it from the latter thickness to 0·5 mm. thick; it is afterwards passed on to the foil rolling mills.

The author wishes to express his indebtedness to The Brightside Foundry & Engineering Co. Ltd., for permission to reproduce illustrations of their mills.

Fig. 8.—26 in. × 52 in. Lauth Three-high mill.



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Institute of Metals

Twenty-fifth Annual General Meeting

THE twenty-fifth annual general meeting of the Institute of Metals was held on March 8-9, at the Institution of Mechanical Engineers, London, under the chairmanship of the President, Sir Henry Fowler, K.B.E., L.L.D., D.Sc. At the business meeting, which preceded the technical sessions, it was satisfactory to note that the Council reported favourably on the progress of the Institute. This is gratifying in view of the prevailing conditions, and the Council is to be congratulated on the efforts made, which have, except in the matter of membership, maintained progress in all phases of the Institute's activities. There can be no doubt that the work and the publications of the Institute are appreciated, and with the return of more normal industrial conditions, the membership will be considerably augmented; meanwhile, the question is receiving the closest attention by the membership, committee, and the Council.

Sir William Bragg was the principal guest at the annual dinner and dance, held in conjunction with this meeting, and he congratulated the Institute on the high order of merit of the work done by its members. During the course of his speech he referred to technocracy, of which a lot had been heard recently, though it seemed to have disappeared as quickly as it came. It is true, he said, that the activities of metal-workers, for instance, had been a tremendous force in moving the world. Movements of peoples and their histories were really far more dependent upon the work of craftsmen than on the battles of kings. The impression produced by pessimistic writings of the day was not true of the hundreds of thousands of people imbued with the craftsman's spirit. He asked them to consider whether it was not time for societies like the Institute of Metals to formulate their own ideas on larger subjects than the mere accumulation of facts, and be prepared to put forward the peculiar outlook of the craftsman as a contribution to social opinion.

In his reply Sir Henry Fowler said he knew of no society whose scientific work had a closer application to practical work than the Institute of Metals. In that connection he called attention to the activities of the local sections, whose contributions of a practical nature were noteworthy.

At the technical sessions some 13 papers were presented and discussed. These covered a wide range of problems and only brief reference can be made to them here.

THE DISTRIBUTION OF POROSITY IN COPPER INGOTS.

The distribution of porosity in typical works copper ingots has been studied by means of systematic density determinations throughout the ingot. Tough-pitch, high-conductivity, and arsenical copper, cadmium-copper, and deoxidised copper ingots have been examined, and a study has been made of certain arsenical copper ingots cast under pressure. The results, which are given in a paper by N. P. Allen, M.Met., show the existence of regular variations of density, the nature of which is discussed.

The conditions revealed by the author's observations are very complicated, and the ingots vary amongst themselves so widely that it is not to be expected that views based on a few samples should have any finality, but the work would lose in value if no attempt were made to trace any regularities which might exist. Neglecting the ingots cast under pressure the author shows it is possible to distinguish between two types of porosity.

(*a*) A porosity due solely to the impurities present in the metal before teeming; this is the general porosity.

(*b*) A porosity due in part to impurities taken up during or after teeming.

In comparing the segregation of porosity with that of impurities in steel, it is shown that while variations from side to centre are greater in the copper ingots than in steel, it is not difficult to pick out from the reports of the Committee on the Heterogeneity of Steel Ingots examples of impurity distributions which fit well in the general scheme proposed to represent the distribution of porosity in copper ingots, and it is clear that processes of the same kind are at work. It has been stated that the pure cone in steel ingots is due to the settling of iron crystals to the bottom of the mould. A similar gravity separation may be held to be the cause of the sound cone in copper ingots, although in this case it is probable that it is the rising of gas bubbles that gives the effect. This is the only place where the effects of gravity separation can be traced. The flow of heat, as affecting the mechanism of differential freezing and the contraction on solidification, appears to be the main factor in determining the distribution of porosity, and it is by the study of this factor that the avoidance of spongy places in castings is most likely to be effected.

THE EQUILIBRIUM OF THE REACTION BETWEEN STEAM AND MOLTEN COPPER.

The work described in this paper, by Messrs. N. P. Allen and T. Hewitt, represents a further stage in the researches undertaken by the British Non-Ferrous Metals Research Association on the porosity of copper castings. It has been carried out at Birmingham University under the supervision of Professor D. Hanson. The importance of the reaction between steam and copper in connection with this subject has previously been emphasised by one of the authors.

In the paper an experimental method is described for determining the equilibrium conditions in the reaction between steam and molten copper, and results are reported which have been obtained over a temperature range of 1,090°-1,350° C., and a water vapour-pressure range of 90-350 mm. of mercury. The behaviour of the system is consistent with the ordinary mass-action laws, and the oxygen dissociation pressure of cuprous oxide has been calculated.

AN X-RAY INVESTIGATION OF THE COPPER-ALUMINIUM ALLOYS.

In this paper the authors, Dr. A. J. Bradley and Dr. Phyllis Jones, review the system from the point of view of Stockdale's equilibrium diagram, which is given in the paper, using the X-ray powder method. Each phase is considered separately, and an endeavour has been made to bring the X-ray work into agreement with the metallurgical investigation. Special attention has been given to heat-treatment.

In agreement with earlier investigators the authors find that the body centred β-phase cannot be attained by quenching; contrary to the experience of Obinata, they found that a homogeneous β structure was invariably produced on quenching the powdered alloy. This structure appears to be closely related to the face-centred α-phase. Obinata's conclusion that alloys quenched from the γ range are indistinguishable from alloys has been confirmed.

The structure of δ-CuAl, up to 19% aluminium, is essentially of the γ-brass type. The arrangement of copper and aluminium atoms was rigidly deduced from photometer measurements, and leads to the formula Cu_9Al_4. The modification of the δ-phase beyond 19%, noted by Westgren, has been confirmed. In the δ phase (19-22·5%

aluminium) the number of atoms in the pseudo-cubic cell falls from 52 to 49.

On quenching a two-phase alloy containing 22·8% aluminium from 700° C., a single phase (ϵ) is obtained, which appears to be cubic. Between this composition and 29% aluminium, the annealed and slowly-cooled alloys show many different types of structure. Stockdale's η-phase, therefore, consists either of a number of phases of small range, or gradual modification takes place.

Friauf's structure for the θ-phase ($CuAl_2$) is confirmed by quantitative intensity measurments. As was found by Westgren, this phase has not a unique composition.

EFFECTS OF HYDROGEN AND OXYGEN ON THE UNSOUNDNESS OF COPPER-NICKEL ALLOYS.

A wide range of the copper-nickel alloys is employed commercially, and all present difficulties in casting unless suitably deoxidised. The deoxidisers used are manganese or silicon, followed by a smaller desulphurising addition of magnesium. Even when these additions are made, however, unanticipated unsoundness is sometimes encountered, and in view of their industrial importance, a study of the effect of gases on the porosity of the copper-nickel alloys is of interest.

Alloys representative of the whole series have been examined. The work is divided into two parts, which deal respectively with the hydrogen unsoundness of the alloys and the porosity produced by a reaction between hydrogen together with oxygen in the metal. In all cases, the soundness of the ingots has been measured by their densities, supplemented by visual and microscopic examination. Where oxygen was present, it has been determined analytically. About ten alloys covering the range have been investigated and the results presented in a paper by Mr. Allen and Dr. Street.

On melting in hydrogen, all the alloys took up enough gas to render them very unsound on casting, the amount of unsoundness varying in a complex manner throughout the series. All the alloys melted in hydrogen could be largely degasified by passing nitrogen over the melt; this degasification was rapid, but was appreciably slower in alloys containing about equal proportions of copper and nickel. Alloys so degasified cast soundly provided the oxygen was absent. When oxygen was present, a second form of porosity appeared, provided that the oxygen exceeded a certain critical content. This "critical oxygen content" varied with the composition of the alloys, and was low for all alloys containing below 30% nickel, and of the order of 0·02% for alloys richer in nickel. The second form of porosity was due to the reaction of oxygen with hydrogen in the melt, and the "critical oxygen content" appeared to be connected with the solid solubility of oxygen in the alloy.

THE APPLICATION OF THE DIAMOND PYRAMID INDENTATION TEST TO COPPER.

The principal object of the work described in this paper which is essentially of a practical character, was to determine the practicability of using smaller loads than those now specified for the purposes of routine control testing of thin metallic materials, and to determine the degree to which "anvil" effect influences the results when standard loads are used. Where thicknesses permit, the usual forms of testing—*i.e.*, tensile, bend, hardness, and cupping tests—are frequently specified and used, both in control and acceptance testing. As the thickness is decreased, the difficulty of satisfactorily carrying out these tests increases and the results become more uncertain and less rapidly reproducible. Although those closely connected with the production of thin metal strip and sheet realise the difficulties associated with the testing of thin metal, very little systematic work on this branch of testing has been recorded, and, because of the absence of information regarding the suitability and applicability of the general forms of testing to thin materials, testing is frequently omitted, or else the normal tests are used indiscriminately, with very unsatisfactory and frequently conflicting results.

The practicability of using the diamond pyramid indentation method for thin strip has been studied by Dr. Maurice Cook and Mr. E. C. Larke, using smaller loads than now specified, and also the degree to which the "anvil" effect influences the results when using standard loads of 5 or 10 kg.

It would seem, from this practical study of the applicability of the test to commercial routine testing of thin materials, that the use of very small loads is neither necessary nor desirable, for the degree of accuracy and consistency obtainable decreases with decreasing load. As the load is decreased, the results are affected to an increasing extent by external factors, such as the surface condition of the material under test, and, moreover, with decreasing load the diagonal length units indicate larger ranges of hardness numerals.

It has been found that copper can be tested under a load of 10 kg. down to 0·010 in. in thickness and under 5 kg. down to 0·005 in. for all ranges of temper, whilst brass and phosphor-bronze for all ranges of temper can be tested satisfactorily down to a thickness of 0·005 in. under a load of 10 kg.

It has also been found that variations in the diamond pyramid hardness of the anvil, within the range of 140-700, have very little effect on the hardness results obtained, except on the materials of 0·005 in. thickness in the hard condition, which yielded low values when tested on the softest anvil used.

NOTE ON THE INFLUENCE OF VOLATILE CHLORIDES ON MAGNESIUM AND ON COPPER.

During the course of the investigation of the effect on the soundness of aluminium castings of treatment of the molten metal with the vapour of volatile chlorides, the influence of these materials on magnesium and on copper was also examined. This note by Messrs. J. D. Grogan and T. H. Schofield described the results of some experiments made in the course of the investigation. The apparatus employed for testing magnesium with the vapours of volatile chlorides was the same as that employed for the treatment of aluminium, and has already been described.[1] The results of the investigation show that the soundness of magnesium is improved by melting the metal under a flux and treating with the vapour of certain volatile chlorides. Treatment with titanium tetrachloride does not produce an alloy molten at the usual casting temperature of magnesium alloys. The density of cathode copper is raised by melting under borax and treating with carbon tetrachloride, but not with titanium tetrachloride. The electrical conductivity of the treated copper is low, probably owing to the absorption of a small quantity of iron by the molten metal during treatment.

EXPERIMENTS ON THE EFFECTS OF VARIATIONS IN MOULD AND POURING TEMPERATURES.

An investigation on the effect of variations in mould and pouring temperatures, separately and simultaneously, on the macro- and micro-structures has been carried out by Francis D. Weaver, B.Sc. (Mrs. Harold Heywood), on the following metals and alloys:—

Common tin, 99·18% pure. (Showing the effects of the usual impurities found in this industrial metal.)
Pure tin, 99·99% pure. (Representing a single phase.)
Tin containing 2% of antimony in solid solution.
Tin-lead binary eutectic—tin 63%, lead 37%.
The antimony-tin-lead alloy—antimony 14·5%, tin 7·7%, lead 77·8%, described above. (This provides results for the type of alloy containing pro-eutectic crystals plus eutectic.)
The lead-tin-zinc ternary eutectic—lead 24%, tin 71%,

[1] *J. Inst. Metals*, 1930, 44, 305-315.

and zinc 5%—was also included in this investigation, but will be carried out at a later date.

The experiments are described and the results reviewed in terms of the constituents present. The primary crystal structure, whether determining the macro- or the microstructure, is shown to be coarsened by raising either the mould or pouring temperature. Cored structures within the crystal grain, generally described as microstructure, are either coarsened or refined by increase in pouring temperature, according to whether the mould temperature is above or below some critical temperature not yet defined exactly.

Interesting crystal structures obtained with pure tin are described. Large crystals appear to be formed at two rates of cooling through the solidification temperature. Strain structures typical of those found in soft metals have been photographed.

THE FATIGUE-RESISTING PROPERTIES OF LIGHT ALUMINIUM ALLOYS AT ELEVATED TEMPERATURES.

The fatigue-resisting properties of some aluminium alloys has been investigated by J. W. Cuthbertson, M.Sc., by means of a modified form of rapid load-deflection test which, the author has shown[2], gives reliable data when applied to steels.

The materials examined were four aluminium alloys and rolled aluminium bar, the alloys being R.R. 56, "V" alloy, and Duralumin; all were heat-treated excepting the aluminium.

The results show that, although the determination of the fatigue-resisting properties of light aluminium alloys by the rapid load-deflection method gives consistent results, yet the curves usually indicate rather too high a value. The discrepancy is not sufficiently great, however, to render the test worthless, and, from a practical point of view, the results are distinctly useful. From the author's investigations it would appear that, if an allowance of 10% be deducted from the figures as determined by the rapid test, the fatigue limits so found will be well on the safe side and agree reasonably with those obtained by the method of endurance.

As the temperature of these materials is raised, the fatigue limit is shown to fall progressively, but still has quite a high value at 300° C. Above this temperature there is experimental evidence that the load-deflection test becomes unreliable and fails in its application to these alloys.

The curves showing the effect of temperature on Young's modulus, under conditions of alternating stress, resemble the fatigue limit-temperature curves.

THE ELECTRICAL CONDUCTIVITY OF ALUMINIUM WIRE.

The experiments described in this paper, presented by A. J. Field, M.Sc., B.Sc., and J. H. Dickin, B.Sc., were carried out, over a period of ten years, in connection with the production of hard-drawn aluminium wire for electrical transmission lines. The paper deals primarily with metal of 99·5–99·6% purity, the standard for aluminium conductors. Electrical conductivity is mainly considered, but attention is also directed to tensile strength, important in overhead transmission lines, which for economic reasons are stressed to the highest safe degree.

The results show that the hot-rolling temperature favourable to conductivity extends over a range from 410° C. to 460° C.; preheating temperatures above 500° C. have a detrimental effect on conductivity. Medium rates of reduction in the breaking-down and intermediate stages of rod rolling give higher conductivity results than heavier rates of reduction. Intermittent rolling in the intermediate and finishing stages is more favourable to conductivity than continuous rolling.

The effect of heat-treatment on hard-drawn wire is to increase the conductivity from an initial low value to a high value at about 300° C., above which temperature there is a decrease in conductivity. A study of the rate of change of properties of hard-drawn wire heat-treated at various temperatures shows that, as 300° C. is approached, a maximum conductivity is attained, accompanied by a complete loss of work-hardness. At lower temperatures the increase in conductivity is slower, and up to 4 hrs.' heating a greater or less proportion of the work-hardness remains intact. Constitutional change on heat-treatment takes place with greater velocity the greater the initial work-hardness on the metal. Cold-drawing effects considerable increase in tensile strength accompanied by a small loss in conductivity.

Practical application of heat-treatment has been considered from the point of view of requirements for various specifications; a satisfactory method of applying treatment has been found to be immersion in an oilbath. As in other metals, purity of aluminium has a considerable effect on conductivity. Regarding individual impurities, the effects of iron and silicon have been studied, the latter having a greater influence on conductivity. The constitutional changes of silicon as affected by thermal treatment are discussed.

GRAPHITIC SILICON, HEAT-TREATMENT, AND THE ELECTRICAL CONDUCTIVITY OF ALUMINIUM.

Much work has been carried out on the forms in which silicon and iron occur in commercial aluminium and its alloys, in order to obtain a better control over the mechanical, electrical, and other physical properties of the metal. One of the questions of greatest interest is that of the solid solubility of silicon in aluminium, as variations in the free and dissolved silicon ratio produced in the metal by suitable heat-treatment are accompanied by changes in properties, more particularly in the electrical conductivity of the commercial metal.

When the author, Dr. L. H. Callendar, commenced his investigations on this subject early in 1927, it became clear to him that a scientific solution of the problem required definitions of the terms free, dissolved, and graphitic silicon, and that unless free silicon was defined as equivalent to graphitic silicon it must not be assumed without experimental evidence that it was equivalent.

The results of the investigation adopting a new method show some effects of heat-treatment of the metal on the graphitic silicon figures obtained from sheet, wire, and cast aluminium. The first separation of graphitic silicon is shown to correspond in certain experiments with the beginning of a rise in the electrical conductivity of the metal. The method used for these experiments seems to give an indication of changes in the form of the silicon in the metal.

THE PHYSICAL PROPERTIES OF ZINC AT VARIOUS STAGES OF COLD-ROLLING.

The primary object of the research discussed in this paper by R. Chadwick, B.A., was to clear up the present very unsatisfactory position with regard to the hardening possibilities, by rolling, of zinc-rich alloys (including commercially pure zinc), and to ascertain with which additions, and to what extent, a permanently hard strip could be produced. With this object in view, the "dead-soft" annealed strip was progressively cold-rolled, the hardness being measured at several intermediate stages. Investigations were confined in the first place to the determination of hardness by means of the Vickers diamond indenter and the Shore scleroscope. It was known from some earlier experiments that the marked creep shown by zinc was very greatly influenced by the amount of cold-work received; measurements of rate of creep were therefore made, tensile strength and yield-point being also measured for comparative purposes.

[2] J. W. Cuthbertson, *J. Iron and Steel Inst.*, 1932, 126.

The amount of work-hardening obtainable by rolling was found to be quite small, and after reaching the maximum hardness further rolling produced a progressive softening. The changes in both physical properties and microstructure found to take place subsequent to rolling have been investigated over a period of three months. The nature of the changes depended on the amount of cold-work which the material had received. The effect of alloying constituents on the changes produced during cold-rolling was comparatively small, but the extent and rapidity of the changes occurring subsequent to rolling were profoundly influenced by small additions of alloying elements. The most notable features of the changes taking place during, and subsequent to, rolling were: the improved physical properties produced by light cold-rolling were permanent, but the accompanying twinned structures failed to persist, and in many cases no twin bands could be observed within a few weeks of rolling. Self-annealing of electrolytic zinc after heavy cold-rolling reductions: softening was found to commence immediately after rolling, and to be complete in periods varying from a few hours to one month. The rate of self-annealing was modified by alloying.

The mechanism of cold-working is discussed, and a theory is advanced to account for the principal changes observed both during and subsequent to cold-rolling.

SOME EFFECTS OF THE ADDITION OF TELLURIUM TO LEAD.

It has been found that lead to which a small amount of tellurium has been added shows an increased resistance to corrosion; exposure tests have shown that the loss of weight of a tellurium-lead, when exposed at the same time and in the same conditions, was only one-seventh of that of the most resistant chemical lead hitherto known. Experiments with tellurium-lead, which shows remarkable resistance to concentrated sulphuric acid, are discussed by Messrs. W. Singleton and Brinley Jones The physical properties of lead are also profoundly affected. The temperature of recrystallisation is increased, and tensile tests carried out on rolled sheet show that tellurium-lead can be permanently work-hardened. The work-hardening can be regulated, so that rolled sheet with a wide range of physical properties can be produced.

It is shown that the material exists in the fully softened condition after normal extrusion, but that it can work-harden under strain. Tensile and freezing tests prove that tellurium-lead in the extruded state will undergo more distortion before fracture than any other metal examined, and it is shown that the character of the distortion is of great value in important practical applications. Fatigue tests on extruded sections indicate a range of $\pm 0{\cdot}50$ tons/in.^{2} on a basis of 10×10^6 reversals of stress without fracture.

Investigation has shown that the effects produced by the addition of tellurium to lead are also to some extent produced by its addition to various lead alloys.

INTERPRETATION OF THE TENSILE TEST. (With reference to lead alloys.)

The usual interpretation of the tensile test in the case of lead and lead alloys becomes meaningless unless attention is given to other factors which arise. In this paper by Professor B. P. Haigh and Brinley Jones, M.Met., consideration is given to certain mechanical principles which govern distribution and localisation of plastic strain in tensile tests, and thus profoundly influence the ultimate tensile strength and reduction in cross-section at the fracture. Lead alloys show wide differences in their types of elongation. Although these differences have important consequences in the practical application of these alloys, they have hitherto received insufficient recognition in the tensile test.

Photographs and stress-strain diagrams of several test-pieces are given, showing that test figures alone do not give an adequate idea of the character of a material. Elongation can be divided into "stable distributed strain" and "local strain." The separation of these types is considered theoretically, and the practical significance of each is discussed. Where severe plastic strains must be expected stable distributed strain is invaluable for delaying fracture.

By means of "ductility diagrams" it is shown that ultimate stress is only indirectly related to fracture, and the conditions for a long range of stable distributed strain are deduced. Necking is discussed, and various types of fracture are mentioned.

The behaviour of the various test-pieces is then discussed, and it is concluded that in comparing ductilities the different types of elongation should be considered. It is indicated that an alloy with a long range of stable distributed elongation should have advantages over ordinary lead in many important applications.

HEAT-RESISTING ALLOY STEEL.

ALUMINIUM and silicon considerably improve the resistance to scaling of high-chromium steels, but render them brittle at high temperatures. In *Stahl und Eisen*, 1932, pages 511–513, W. Oertel and A. Schepers present data on such steels to which nickel had been added to counterbalance the harmful effect of aluminium and silicon. The tensile strength was determined at temperatures from 700° to 1,000° C., and the degree of scaling after heating the steels at temperatures from 900° to 1,200° C. in an electric furnace for 36 hours. The properties of the best steels were as follows:—

Composition %.

C.	Si.	Ni.	Cr.	Al.
0·31	2·53	8·00	18·6	0·56
0·29	1·88	8·24	19·5	0·15
0·30	3·20	7·6	17·8	Trace

Tensile Strength Tons per Sq. In. at			Elongation, % at			Reduction of area, % at			Scaling at 1,200° C.
700°	900°	1,000° C.	700°	900°	1,000° C.	700°	900°	1,000° C.	Mg./cm.²
23·4	6·35	3·24	16	15	24	20·8	21·8	29·4	9·4
28·5	8·97	5·82	24	14	12	38·6	26·1	24·3	6·0
33·2	9·39	5·59	29	30	38	40·7	67·5	62·4	4·3

EFFECT OF TEMPERATURE AND IMPURITIES ON THE ROLLING PROPERTY OF ZINC.

ACCORDING to experiments made by O. Bauer and P. Zunker, the rolling properties of electrolytic and refined zinc are improved with increasing rolling temperature.* At 110° C. both sorts can be rolled free from surface cracks. Refined zinc, however, shows at this temperature and at 130° C. small fissures at the edges which disappear when rolled at 150°. With increasing temperature and degree of deformation the coarse-grained as-cast structure changes more and more into the fine-grained rolling structure. With electrolytic zinc this change starts and finishes sooner than with refined zinc, which fact can be ascribed to the action of the impurities present in the latter sort. Their effect on the rolling property of refined zinc is as follows: Up to 1% lead has no effect. Cadmium when present in quantities exceeding the solubility limit markedly impairs the rolling properties. At temperatures higher than 110° C. copper up to 1% has no perceptible effect. Iron, even in small quantities, is harmful; its effect, however, can be counterbalanced by increasing the rolling temperature above 150° C. At a sufficiently high temperature, antimony when present even in rather large quantities is relatively innocuous. Tin exerts the most harmful effect, which cannot be compensated by increasing the temperature because of the formation of a ternary eutectic having a low melting point.

* *Zeitschrift fur Metallkunde*' August, 1932, pages 191-192.

The Naeser Colour Pyrometer

By M. A. Vernon, M.A., Ph.D.

A new optical pyrometer in which temperature measurement depends upon variation in colour. With this instrument it is claimed that absolute error is less than with the usual type of optical pyrometer.

THE accurate measurement of high temperatures in cases where an immersion pyrometer cannot be used has always been a problem of peculiar difficulty, and the optical pyrometer, which is used in the majority of such cases, is open to several objections.

One of these is that the measurement will depend upon a comparison of the radiation from the body under consideration with black body radiation. As in all practical cases the former is less than the latter, the apparent temperature will always be less than the true temperature. If, on the other hand, the measurement were made to depend upon the variation in colour—*i.e.*, the ratio of intensities of radiation of different wave-lengths, this difficulty would disappear. A new source of error would be introduced, however, in that the emission from most hot bodies met with in industrial practice is stronger in the short wave-lengths, and in consequence the apparent temperature would be higher than the true temperature. This is only true in the majority of cases ; in some instances the difference might be zero, or else in the opposite direction, but in practically every case the absolute error would be much less than that caused by the use of, say, either a disappearing filament or total radiation pyrometer.

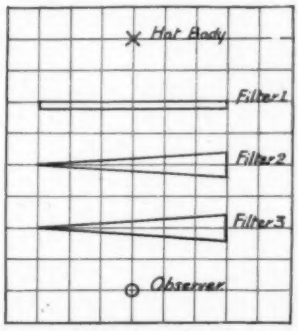


Fig. 1—A graphic indication of the theory of the instrument.

An instrument functioning on this principle has been devised by Gerhard Naeser, of the Kaiser-Wilhelm-Institut in Düsseldorf, and has been successfully used for measuring high temperature.

The theory of the instrument may be readily understood by reference to Fig. 1. Light from the hot body passes successively through three filters to the eye of the observer. Filter 1 transmits two colours only—say, red and green, for simplicity. Filter 2 absorbs red light in gradually increasing amounts, but transmits green, whilst Filter 3 absorbs green and transmits red. If Filters 2 and 3 were absent, the eye would receive a mixture of red and green radiation, compounding to form a resultant tint depending on the temperature of the radiating body. At a certain temperature it will match some arbitrarily chosen standard tint—say, white,—and will appear green or red at temperatures respectively above or below this. Suppose the tint appears green, then by suitably altering the position of either Filter 2 or Filter 3, an increased proportion of green light could be absorbed, and the resultant tint brought back to white. If Filter 2 absorbs more strongly than Filter 3, the two filters could be rigidly joined together, and the desired effect obtained by moving them bodily in the required direction. As Filter 1 is uniform, this could also be joined to the other two, and this is the arrangement adopted in practice. Actually, an eyepiece is made to slide along the compound filter, a pointer on the eyepiece moving along a rigid scale of temperatures on the filter, so that the required temperature is read off directly.

In the analysis above it has been assumed for simplicity that the component colours are red and green. As a matter of fact these are the colours actually chosen, but the choice was not made without careful consideration, and the factors governing the choice are worthy of note.

The highest temperature which can be measured with a device of this sort is 3,000° C. ; in actual practice it will not generally be required to measure temperatures below 500° C. or above 2,000° C. The practical lower limit will depend upon the colours chosen, and in the case of the less emissive bodies, such as bright metals, the limits are 600° C. in the red, 750° C. in the yellow, 900° C. in the green, and 1,000° C. in the blue. Thus, for lower temperatures, colours will have to be chosen in the long-wave portion of the visible spectrum.

For the greatest accuracy the colours chosen must also be such that as the eyepiece is moved along the wedge one component predominates, until there is a sudden change to the standard compound tint, followed immediately by a change to the other colour. This condition is satisfied by making the colours complementary and the standard tint white.

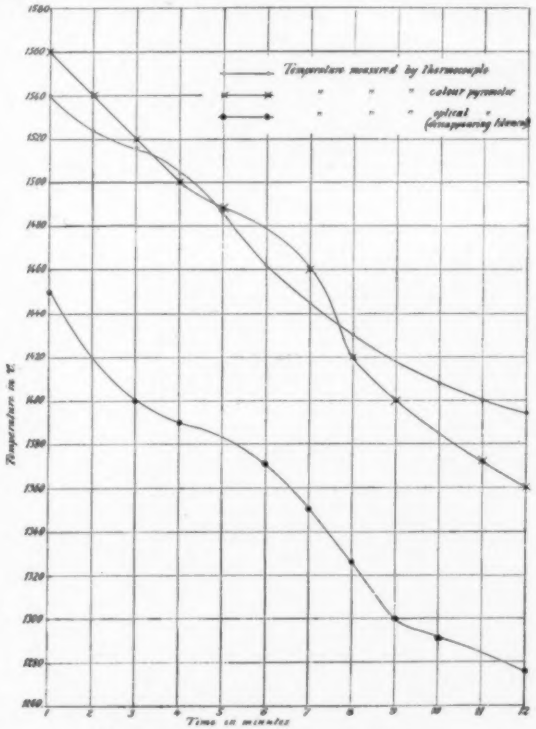


Fig. 2—Cooling curve of molten iron.

In designing an instrument of this type, physiological considerations become of great importance. It must firstly be remembered that the eye is most sensitive to the yellow, and to its neighbouring spectral colours, orange and green, and that to produce a sensation of colour at all, the incident light must be at least of a certain minimum brightness. If, on the other hand, the light is too bright, dazzle will ensue, and all colours will tend to appear whitish. The latter defect may easily be corrected by a grey filter, but the former has no simple remedy ; thus it is advisable to choose colours to which the eye is very sensitive.

There remains the question of colour fatigue. If the eye observes one of the component colours for too long, it becomes relatively insensitive to it, and in making the measurement the neutral point will be displaced in the direction of this colour. It is therefore important when making measurements to move the eyepiece to and fro about the neutral point fairly quickly, before finally stopping at the neutral point.

From a physiological point of view, it is found that green-red and yellow-blue are the best colour pairs.

The filters are made in practice by enclosing solutions of organic dyes in glass cells. If the colours are A and B, three dyes have to be found, one of which absorbs A and transmits B, one which absorbs B and transmits A, and one which transmits A and B, but no other colours. Three such dyes cannot be found for the blue-yellow combination, and therefore the green-red combination is adopted in practice.

Practical Tests.

Measurements made (in Germany) by a number of observers using these instruments, of the temperatures of the same hot bodies, showed extremely close agreement, indicating that for operators of normal colour vision the personal error is very small. A completely colour-blind operator could not use the instrument, but partial colour blindness could be corrected by suitably altering the concentration of the appropriate filter solution. In this case, of course, the instrument could be used by that particular operator only.

As a practical test, a cooling curve for molten iron was plotted, the temperature being measured by (1) a platinum-platino-rhodium thermocouple in a 2 mm. protecting sheath; (2) an optical pyrometer; and (3) the colour pyrometer, readings being taken simultaneously by three observers. The results, plotted in Fig. 2, show clearly that the "colour temperature" shows more slight irregularities than the temperature as measured by the optical pyrometer, yet it approximates far more closely to the true temperature. All three instruments were checked before and after the experiment against the melting points of pure gold.

It is suggested that one eye be used for preliminary rough adjustments and the other for fine adjustments (in case the first eye is fatigued), and it is claimed that under these circumstances, after a little practice, an accuracy of 1 or 2% may be assured.

Sheet Mill Extensions at Jamshedpur Works

CONSIDERABLE progress is being made at the works of the Tata Iron and Steel Co., Ltd., particularly in regard to the sheet mill, which is being extended in two stages, the first of which is expected to be ready for operation this month. This extension embraces one continuous pair and one continuous pack furnace, which are installed. Bars in pairs will be charged by hand at the charging end of each half of the pair furnace, as each pair is delivered on to the discharge end to the roughing stand. The pair furnace will be 50 ft. long and about 8 ft. wide inside the brickwork, and will carry rows of bars stacked singly. Each half of the pair furnace will deliver to the roughing stand, where complete roughing will be done to the same length and gauge for the final finishing pack length and gauge. The continuous pack furnace is about 55 ft. long by 8 ft. wide inside the brickwork, and is designed for two rows of packs. Each side of half the pack furnace can be operated independently, and both sides or halves will discharge directly on to a feeding table of the finishing stand. These furnaces and the galvanising pots will be fired with coke oven gas.

Power conveyers have been installed which will return the matched bars from the back side of the roughers to the charging end of the pack furnace, and conveyers will also return the doubled packs from the back side of the mill to the charging end of the furnace. The installation also includes a new mechanical doubler. In order to handle the additional tonnage resulting from the developments, the bar storage building, the black-sheet storage, and warehouse buildings have been extended.

The sheet mill, for producing plain and corrugated galvanised and black sheets, consists of nine finishing mills, together with roughing stands, one drag, and two cold mills. Facing the mill from the rollers or furnace side the stands are arranged from left to right, as follows:—29 in. × 29 in. drag rolls, 30 in. × 48 in. finishing rolls, 30 in. × 48 in. jump roughing rolls, two stands, 30 in. × 48 in. finishing rolls, 30 in. × 48 in. balanced roughing rolls, 30 in. × 66 in. finishing rolls, motor and gear drive, 30 in. × 42 in. finishing rolls, 30 in. × 42 in. jump roughing rolls, 30 in. × 42 in. finishing rolls, three stands of 30 in. × 36 in. finishing rolls. Coupled with these stands, and operated from the same drive, are the cold mills, with one stand of 26 in. × 42 in. rolls and one stand of 26 in. × 54 in. rolls. All these mills are driven through reducing gears from a 1,500-h.p., 3,000-volt induction motor.

The sheet bar mill consists of six stands of 24 in. continuous rolls and six stands of 18-in. continuous rolls, which follow the blooming mill and further reduce blooms and slabs into billets for the merchant mill, sheet bars for the sheet mill, sections for the sleeper plant, and tin bars for the Tinplate Co., of India. All these sections, except sleeper bars, are rolled direct, after passing through the blooming mill, without any reheating. The mills are driven by electric motors through Falk speed-reducing gear sets—a 2,300-h.p., 3,000-volt motor for the 24-in. mill, and a 4,000-h.p., 3,000-volt motor for the 18-in. mill.

With the extension a rearrangement of power units has been made, and the 2,300-h.p. motor for driving the 24-in. continuous mill, with a new double reduction gear set, has now been put into operation on the new unit in the sheet mill. Further, the 4,000-h.p. motor formerly employed for driving the 18-in. continuous mill will now drive the 24-in. continuous mill, and a new 7,500-h.p. motor will drive the 18-in. continuous mill.

This new 7,500 h.p. slow-speed synchronous motor, which will run at 94 r.p.m. from a 6,300-volt three-phase a.c. supply system, was built by the British Thomson-Houston Co., Ltd., at Rugby. The full capacity of this motor will not at first be required, but it is the intention to roll sheet bars 16 in. wide on the continuous mill in order to relieve the amount of hand roughing necessary in the sheet mill with the narrower bar. It is anticipated that the mill will impose peak loads of nearly 19,000 h.p. on the new motor.

Installations resulting from this extension include a new "Taylor" pickling machine, with four vats, and a complete new galvanising machine in the finishing department. The latter is being equipped with additional corrugating machines, ridge presses, dial scales, tractors, transfer cars, etc. New cranes are installed in the bar storage yard, sheet-mill furnace building, hot-mill building, black-sheet storage and warehouse building. A new additional air-cooling apparatus is also installed.

This extension is expected to increase the capacity of the works for the production of sheet to nearly 65,000 tons a year. Further extensions contemplated will not affect the output for at least another year, but it is expected that, ultimately, production capacity will be increased to over 90,000 tons.

Recent Developments in Tools and Equipment

A NEW COMPRESSION TESTING MACHINE

THE use of testing machines of large capacity is becoming of increasing importance owing to the necessity for testing large specimens in investigating the properties of concrete and reinforced concrete, and for testing materials in fabricated form. In the testing of concrete it is also highly desirable that the rate of loading should be controllable.

A 500-tons-capacity compression testing machine which fulfils these conditions has recently been installed in the Civil Engineering Department of the University of Birmingham. This machine may be used for specimens up to 11 ft. in length. Its overall height is 18 ft. 6 in., but it is sunk 3 ft. 9 in. below the floor, to facilitate the positioning of the heavy and cumbersome specimens. The total weight is approximately 12 tons.

The machine is arranged for automatic load indication, and although it is of large capacity it is easily controlled by one operator, who may control the rate of loading by following a pointer actuated by a block mechanism provided with a changing gear system. Hydraulic pressure is utilised for both the straining and load-indicating operations. The principal units of the machine are the straining gear, the pumping set, and the load indicator.

The Straining Gear.

The straining portion comprises mainly a cylinder and ram, two columns carried from lugs on the cylinder, and a top crosshead supported upon the columns. The columns are screwed to provide means for the adjustment of the top crosshead.

The cylinder is a steel casting fitted with a phosphor-bronze liner. The ram, which has a stroke of 9 in., carries a cupped crosshead, in which rests the bottom spherically seated platen. This steel platen is machined to 20 in. square, and is suitable for testing specimens up to 18 in. square. It is faced with a steel plate, on which are scribed location lines for the centralisation of specimens.

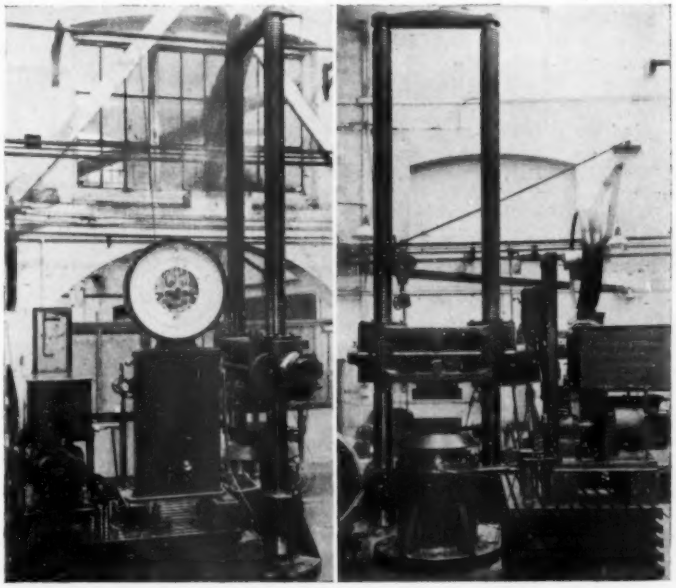
In order to permit tests to be carried out with fixed or rigid bottom platen, a steel ring has been provided which may be inserted under the lip of the platen, thus preventing the platen from operating in its spherical seat. As the machine is designed primarily to test concrete and similar material, liable on fracture to produce dust, etc., likely to damage the ram of the machine, a suitably shaped guard is fitted immediately beneath the lower platen.

The phosphor-bronze nuts are rotated by worm gearing arranged at the front of the machine. The worm shaft is driven by a 1½-h.p. constant-speed motor through reduction gearing, to give a crosshead adjustment speed of 4½ in. per minute. The motor and gearing are mounted on a bracket at the side of the crosshead, and move with it. Press-button controls for the motor are arranged immediately above the motor starter. An effective system of limit switches is arranged to safeguard against damage from possible overrun of the crosshead.

The hydraulic pressure to the cylinder is provided by a motor-driven oil-pumping set of the reciprocating-ram type. A specially compounded oil is used, which, although of comparatively low viscosity, has particularly high surface-tension properties.

A momentum valve is interposed between the control valve and the main-load cylinder, and serves to eliminate any pulsations which may be set up by the pump, and to further ensure absence of pulsations at the load indicator.

The load indicator is provided with two reading dials, one at the front and one at the back. It is of the cam resistant type, arranged on a cabinet, at a height convenient for the operator. In the cabinet are arranged a small pressure cylinder and a lever system in connection with the dial indicator. The dial is provided with two ranges of graduations, from 0 to 500 tons by ½-ton divisions, and from 0 to 250 tons by ¼-ton divisions. The reading line is 28 in. diameter, whilst the chart is shadowless, avoiding parallax errors. A change-lever system under the control of a hand-lever conveniently arranged at the front of the cabinet, is provided to facilitate immediate change from one capacity to another.



Front and side view of a new compression testing machine.

A novel feature is the timing mechanism secured to the glass cover of the front dial. Of a construction similar to that of a clock, it is provided on its main spindle with a finger, which projects inside the glass of the front dial in close proximity to the load-indicating pointer.

When required for use, the gears of the clock are set to give the speed corresponding to the rate of loading required. The clock finger is brought opposite to the load-indicator pointer and the clock set in motion. The control valve to the main cylinder is then regulated to maintain a loading speed in sympathy with that fixed by the clock. When a specimen fractures, the load-indicating pointer returns to its zero position, and in order to retain the indication of the load at which the specimen fractures an electro-mechanical device is fitted to the rear dial.

This machine, unique in several respects, has been specially designed by W. and T. Avery, Ltd., Soho Foundry, Birmingham, to meet the requirements of Professor C. Batho, D.Sc.M.I.C.E., M.I.Struct.E., of the University of Birmingham.

Modern Steam Meters.

IN order to obtain efficient results in the metallurgical and allied industries, it is necessary to keep an accurate and continuous record of the amount of steam used, and that the difficult problems of steam metering have now been solved is well indicated by the latest designs of the "K M" meter of George Kent, Ltd., Luton. This also is suitable not only for steam, but also compressed air and gas, as well as liquids, such as water and oil, and is specially intended for general industrial conditions, with any diameter of pipe.

The operation is on the "orifice" principle, a Monel metal fitting, of circular or "chord" design, being inserted in the pipe-line, being of lesser cross-sectional area, so as to cause a constriction. Consequently, a slight difference in pressure results between the "up-stream" and the "down-stream" sides of the orifice plate, which, under conditions of correct design, is proportional to the square of the amount of steam or other medium passing.

The firm have long specialised in the field of flow meters, and they make a wide range of instruments of different types for use according to the operating conditions. With the "K M" meters, as with other of their designs, various standard orifice fittings are used according to the conditions, typical of which is the "D" design, consisting of a circular steel carrier or frame fixed between the flange of the pipe which carries the orifice plate, either circular or of the "chord" design as stated. Included in the carrier are two pressure holes, which for steam connect to two short vertical cooling chambers filled with condensed water. One of these holes is coupled to the up-stream side of the orifice and the other to the down-stream, and both are connected by narrow bore copper pipes to the "power unit," which actuates the indicating and recording portion.

In the "K M" meter this is essentially a mercury "U" tube, being two vertical weldless steel cylinders connected at the bottom by a narrow diameter curved steel pipe. One of these cylinders has a float, riding on the surface of the mercury, which operates a gland spindle, connected by a rod and arm mechanism to the indicator and recorder, the gland being of special design, almost frictionless, and quite leakproof, while over the top is a horizontal pipe from the orifice fitting, with a vertical valve-controlled connection to each half of the "U" tube below.

So far as the records are concerned, the "K M" meters are supplied in a variety of forms—an indicator only, recorder only, combined indicator and recorder, combined recorder and integrator, and combined indicator, recorder, and integrator. Also, there is available a recorder meter with a separate recording device on the same chart for the pressure.

The simple indicator, for example, type "K M/I" consists of a 12-in. dial with a pointer moving round over an angle of 270°, the scale being marked in pounds of steam per hour (or any other unit), the accuracy at full load to half load being plus or minus 2%, and at only one-sixth load accurate to plus or minus 4%, which applies to all the types of "K M" meter. Also, the combined indicator, recorder, and integrator type "K M/C I D" has a clock-work driven circular chart, 12 in. diameter, and a pen giving a continuous curve in pounds of steam per hour or other figure, while the indication is read off by a pointer moving through an angle of 270° in conjunction with black figures marked on the glass front of the instrument, and the integrator or counter device in the framework above the chart.

Boiler Feed-Water Regulators.

An Automatic Pressure Control Valve.

IN connection with the operation of feed-water regulators on a battery of water-tube boilers, such as those commonly employed in the iron and steel industries, it is often advisable for the best results to include automatic pressure regulators in the feed-pipe circuits. This ensures that the pressure is always uniform at each individual regulator, irrespective of the great variation always liable to occur in a long feed main.

For example, with centrifugal feed pumps now so largely used, a drop in pressure always takes place as soon as a heavy load comes on, with a rise in pressure under conditions of reduced load. Also, there are the complications involved as regards friction in the feed main, and particularly the fact that one or other of the boilers may be banked-up or only running on very low load as compared with most of the other boilers. As a result, considerable differences of pressure occur, which affect the efficient operation of the feed-water regulators.

In this connection great interest attaches to the latest design of the Copes Type "S S" pressure regulating valve for use in conjunction with the Copes feed-water regulator, which, as is well known, operates on the thermostatic principle with an inclined straight metal tube and lever connection to a balanced pump control valve. The "S S" valve is fixed in the branch feed-pipe for the boiler, between the ordinary control valve operated by the thermostatic regulator and the feed pump, and keeps the pressure constant at this point, irrespective of the variations in the main feed-pipe connecting to the pump and the branches to the various boilers.

Consequently, as already indicated, each individual feed-water regulator on a boiler plant of any size is able to operate at the highest efficiency because of the uniform pressure in the water passing through.

Essentially in design the "S S" pressure regulating valve, supplied by Copes Regulators, Ltd., 231, Strand, London, W.C. 2, is a cast-steel unit in a range of standard sizes, 2 in. to 6 in. diameter, having in the top portion a 4-ply brass bellows device operating in a vertical direction, connected by suitable linkwork to the control valve.

The outside of the bellows is subjected to the water pressure in the main at the inlet of the feed-water regulator valve, while the inside of the bellows is subjected to the water pressure on the discharge side of the feed-water regulator valve, by connection of a small-bore pipe. An adjustable sliding weight on a lever is included, which is set to any desired maximum pressure difference allowed between the inlet and outlet side, generally within the range of 10 lb. to 25 lb. per sq. in., and the bellows operates accordingly, giving a vertical motion at the vertical link, and operating the valve, which is opened or closed automatically to a very slight degree, maintaining the pressure uniform at the feed-water regulator.

Further, the "S S" valve is now suitable for all conditions up to about 600 lb. per sq. in. pressure, and a considerable number of plants are equipped in Great Britain.

"Adra" Fans.

It is of interest to note that Fraser and Chalmers' Engineering Works (Proprietors: The General Electric Co., Ltd.), Erith, are now manufacturing under licence "Adra" fans to the de Raedt design, by agreement with Messrs. Scott and Strutt, Ltd., 25, Victoria Street, S.W. 1, who are the sales organisation. This type of fan has established a very good reputation on the Continent with particular reference to the heavy industries, mining, metallurgy, power generation, etc., and the ventilation of the new tunnel under the Schelde at Antwerp is effected by 24 special fans of this design. This scheme is said to be one of the most efficient of its kind in existence.

Among a number of interesting specialities connected with Adra fans, perhaps the most outstanding is the patent intake distributor. This device, which is designed for use with fans handling dust-laden gas and air, pulverised fuel, etc., has the effect of greatly prolonging the life of the fan runner and casing. Indeed, in actual replacements of existing plant, figures have been obtained which show that the fans now give more than four times the number of working hours previously obtainable. This should be of the greatest interest to all who study and effect power generation, for the erosion of the induced-draught fan is often a very serious problem.

The British Industries Fair

Some additional features that proved of outstanding interest.

It is not possible to determine the results obtained from the British Industries Fair but the general opinion expressed by exhibitors was one of satisfaction. The actual number of orders booked has not perhaps reached expectations, but very promising enquiries make it difficult to estimate the real value of the effort. The Fair is largely regarded as a means of propaganda and personal contacts are made which are unlikely to be made in any other way, with the result that, though orders may not be immediately forthcoming, business connections are eventually made.

One of the great advantages of an Exhibition of this character is the facilities afforded for investigating products that give superior service under the more exacting conditions now imposed. Buyers are thus kept in touch with progress and they can readily determine to what extent their own manufactures are likely to be improved by making use of certain developments.

In addition to the exhibits referred to in our survey published in the last issue a number of machines and appliances attracted considerable attention. It is appreciated that foundry equipment and machines always have a popular interest, as well as a trade interest, and the demonstrations of Pneulec, Ltd., certainly attracted much attention. A jarr roll-over machine was on view, having a turnover plate 20 in. × 36 in. This is the smallest of the range of these machines, and is capable of jarring

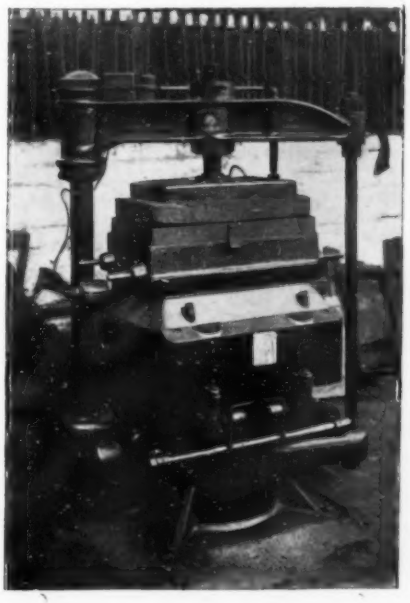


Fig. 28.—Magnetic moulder of new design.

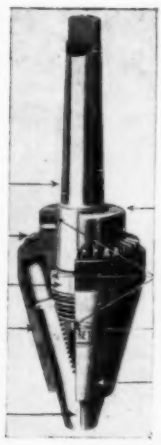


Fig. 29.—New design of drill chuck.

a mould, rolling it over, and stripping the pattern in 1 min. The magnetic moulder (Fig. 28) shown by this firm was of new design ; there are few moving parts, and operating costs are remarkably low. A new exhibit, a sand milling and mixing machine, was also included.

Comprehensive ranges of Skefko ball and roller bearings included single-row ball bearings, double-row self-aligning ball bearings, taper roller bearings, cylindrical roller bearings, and single and double thrust roller bearings. All who are associated with power transmission equipment would find it profitable to inspect the exhibits of the Skefko Ball Bearing Co., Ltd. An entirely new line of drill chucks

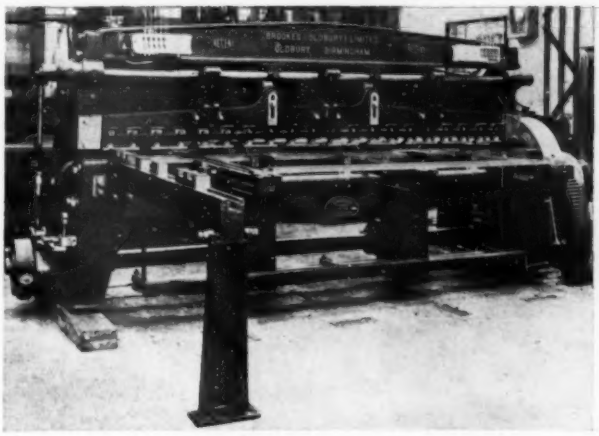


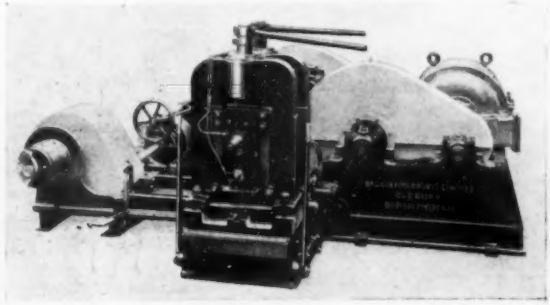
Fig 30.—High-speed undercrank-type guillotine shears.

is being introduced by the Brooke Tool Manufacturing Co., Ltd. These drill chucks have many advantageous features ; they have to be treated under most exacting conditions, and have given entire satisfaction. Their construction will be noted in Fig. 29.

Special attention has been given to the adjustment of the blades ; in addition to the horizontal standard adjustment, vertical adjustment is provided to the bottom blade in the high-speed undercrank-type guillotine shears (Fig. 30) exhibited by Brookes (Oldbury), Ltd., in order that the cutting edge of this blade may be maintained flush with the top of the table after regrinding. Features of this kind have a considerable influence on the serviceability of shears, and the ease by which they can be maintained in use. In addition to several shears, this firm exhibited an automatic wire-chain-making machine. It is specially designed for the manufacture of flat-backed mattress chain from wire, and is a typical example of the range of wire-working and strip-forming machines marketed by this firm. The machine is a compact type, direct driven by an electric motor through Vee belts, starting and stopping being controlled by a friction clutch.

Many types of rolling mills have in the last few years been put before the manufacturer of cold-rolled strip, all of which have undoubtedly had their particular use, and Messrs. Brookes have now added to this range of machinery with their new standard two-high mill, which embodies all the best features possible for the finishing passes. The mill is standardised in four sizes—6 in. to 8 in., 10 in., and 12 in. diameter rolls, and is arranged with variable-speed gear (Fig. 31), giving rolling speeds from 90 ft. to 270 ft. per

Fig. 31.—New standard two-high mill.



min. The method of reducing from the motor to the mill is through double reduction gears, and a flexible coupling is interposed between the gearing and the motor. For starting and stopping the mill an improved type of friction clutch is fitted on the intermediate shaft, and particular care has been taken to ensure that the least possible pressure on the hand levers will operate this unit. All gears are totally enclosed, and all parts are adequately guarded to meet the requirements.

An interesting feature of this mill is the method of lubrication of the roll-neck bearings. The system of independent supply of oil to each neck has been developed, and any excess of oil is drained away by a system of collectors bringing the used oil to a central point and

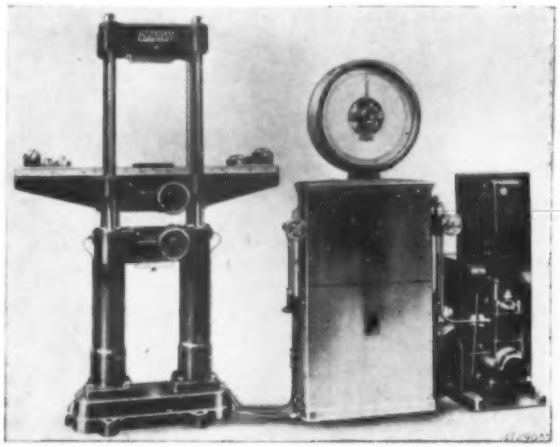


Fig. 32.—*Visible indicating universal testing machine.*

avoiding any waste. Another interesting feature is the care which has been taken to ensure absolute rigidity in the roll housings and in the bedplates. A 40-in. enlargement of this mill, exhibited by Messrs. Brookes, attracted much attention.

Cold-forging machines were exhibited by Greenwood and Batley, Ltd. The cold process of manufacturing bolts, screws, and rivets of all shapes, both in steel and in non-ferrous metal, has been developed to such a degree that the products are now universally used throughout the engineering trades. For large quantities, machinery for cold heading and its subsidiary operation is an economical proposition. Cold-heading machines for this purpose were shown, together with an automatic screw-forging machine, and an inclined-thread rolling machine.

Testing Machine and Appliances.

The visible indicating universal testing machine (Fig. 32) exhibited by W. and T. Avery, Ltd., and which has been erected for practical demonstration, attracted considerable attention. It is claimed for this machine that standard forms of physical test can be applied more quickly than with the non-self-indicating type of testing machine, and with precision. This formed only a part of the striking display by this firm, which included a number of working machines. The Scientific Instrument Section of the British Industries Fair was situated in the Grand Hall at Olympia, and occupied approximately 14,500 sq. ft. of space, nearly 3,600 sq. ft. of which was taken for a composite exhibit of British scientific instrument manufacturers. The entire exhibit may roughly be divided into two sections—(*a*) technical instruments which comprised the equipment required for control testing by works chemists, apparatus for laboratory research, and apparatus designed expressly for the teaching of sciences in colleges and schools; (*b*) scientific instruments of a more or less domestic nature.

A remarkable instrument exhibited by Cooke, Troughton and Simms, Ltd., was the Vickers projection microscope (Fig. 33). This apparatus is entirely different from the conventional form of microscope, and is designed primarily for the use of metallographers, for studying the structure of metals and other objects, whether opaque or transparent. It will take specimens up to 50 lb. in weight, and magnifications can be obtained from 3 to 5,000 diameters. In addition to visual observations, the apparatus will also take micro-photographs, or, if desired, the image can be projected on to a screen for demonstration purposes. The Cooke optical comparator is an instrument designed for quick and accurate comparison of machine parts produced in quantities. A total magnification of 1,000 is achieved, and a variation of 0·0001 of an inch from standard parts is represented on a dial.

Fig. 33.—*Vickers projection microscope.*

The manufacture in this country of extremely delicate analytical balances for research chemists is a comparatively recent venture. It is pleasing to be able to record that this country can produce analytical balances equal, if not superior, to the foreign article, both in performance and workmanship and at competitive prices. An example is the "Nivoc" analytical balance, a pattern which is greatly favoured in the laboratories of universities and technical chemists. It is of simple design, with little to get out of adjustment, but very much more elaborate balances are obtainable, fitted with special devices to obviate the use of the very small fractional weights, to damp the swing of the beam by means of oil and pneumatic plungers, thus allowing the balance to come quickly to rest, and microscope and optical arrangements to facilitate the reading of the very fine scale graduations.

Students and designers should not overlook the ranges of drawing instruments and slide rules which were exhibited by A. G. Thornton, Ltd. The P.I.C. calculating slide rules introduce new designs and constructions for students; also slide rule for engineers, with a new compound differential scale and a new design of index reader for the electrical scale. The compound differential scale is worthy of special notice, for its addition to slide rules having log scales considerably extends the range of work possible on these patterns. A close inspection of the instruments showed that British productions have no superiors.

We regret to announce that Mr. Albert E. Robinson died on Thursday evening, March 9. Mr. Robinson had represented the Carborundum Co., Ltd., Trafford Park, Manchester, for 18 years, during which time he made himself a very popular figure in the Lancashire area.

Some Recent Inventions.

Apparatus for Welding Tubes

CONSIDERABLE progress has been made in the development of electric welding during recent years. Many welding processes and machines have been produced and operated for the continuous or intermittent welding of materials such as tubular shapes, the majority of which have assisted in this general progress, but certain difficulties have arisen. In most cases commercial installations have been designed to operate on the basis of supplying current by means of stationary or moving contacts in engagement with different portions of the pipe surfaces. In order to secure efficient operation of such types of apparatus, it has usually been necessary to subject the material to a preliminary cleaning, such as an acid dipping, or a mechanical cleaning operation either at the seam or adjacent the edges, or both, in order to ensure not only a clean seam, but also the proper contact conditions for the output of the necessary welding current

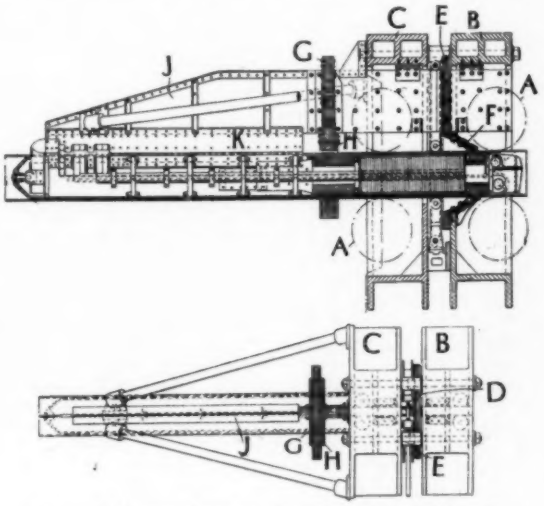


Fig. 1.—Plan and elevation of apparatus for welding tubes.

A new apparatus has been devised which is claimed to provide a method of welding which is not dependent upon any pre-cleaning or special treatment of the sheets or other materials which are to be welded. It thus offers the advantage of eliminating an expensive handling and pre-treatment operation. In addition, it is claimed to provide a welding method which forms a continuous weld throughout the complete thickness of the material and of uniform characteristics throughout the seam. This method and apparatus will, for instance, effectively weld material having a thickness of one inch at a rate of approximately 30 to 50 ft. per min. It is further claimed that the method produces an article sufficiently straight to render any subsequent straightening operation unnecessary. This is possible as a result of concentrating the heat almost entirely at the seam, so that the maximum expansion of the metal of the article welded is insufficient to produce camber or other deformation.

In contrast to the contact method in which a mechanical or electrical contact is necessarily established between the material to be welded and a suitable conductor, in this method the heating current is supplied inductively. Although not limited to the flash method of welding, this device is particularly adapted to it. In general, however, it may be characterised as a combination of flash and resistance welding at different points progressively throughout the length of the material during its continuous movement. The flash method of welding has a short flame, and since it is spread uniformly throughout a considerable part of the length of the article, it maintains the edges in a uniform condition.

A plan and elevation of the apparatus is shown in Fig. 1, from which it will be seen that the welding is accomplished entirely between two roll passes A A. In the upper portion of housings B and C, and extending through them is a laminated yoke D. Co-operating with this yoke is a pole piece E, which is also preferably laminated, and which is provided with a central opening of somewhat greater diameter than the maximum diameter of the material to be welded in the apparatus. In the pole piece E are individual pole pieces F, each projecting towards the centre of the pass of the working rolls. It has been found advantageous to construct the individual pole pieces so that they are effective for providing a magnetic flux path extending within the zone defined by the peripheries of the working rolls.

When the apparatus is desired for relatively short lengths, a second pole piece G is provided, similar to the pole piece E. This also carries an inner laminated liner H, and is adapted to receive the material, but without making contact.

Where the apparatus is designed for use with relatively long pieces of material, or for continuous welding-up-operations, the pole piece G and its co-operating parts may be dispensed with entirely. In such cases the magnetic yoke D may be continued rearwardly in the form of an overhung laminated beam J suitably supported by struts or stays from the housing C, the beam J being of suitable construction to provide the desired continuation of the flux path established by the yoke D, such laminated continuation extending clear down to a central core K, and being integrally associated with it.

373,162. THE YOUNGSTOWN SHEET AND TUBE CO., assignees of JAMES DUNCAN ADAMS, JNR, both of Ohio, U.S.A. May 17, 1932.

Aluminium Alloys Containing Tin

A METHOD of incorporating tin in aluminium or in aluminium alloyed with small quantities of other metals such as manganese, lead, etc., is claimed by displacement from tin oxide by reaction with magnesium in the form of an alloy with copper or zinc. The magnesium alloy may contain 90% of zinc, and is made by melting the metals together in a reducing atmosphere. This alloy is prepared first, and after being divided into small parts is covered with tin oxide powder, preferably mixed with zinc oxide, to render it porous. The reduction takes place in a crucible at red heat in a reducing atmosphere. After raising the temperature to the melting point of aluminium or over, aluminium or aluminium alloy is added.

The amount of magnesium alloy employed, having regard to its magnesium content, may be just sufficient to reduce the tin oxide, or an excess may be used when magnesium will be present in the final alloy in addition to the other metals such as copper, zinc, etc. The cast ingot while hot may be further treated with steam, and for rolling it is first heated to about 150–200° C., and then rolled at this temperature while being subjected to the action of steam. Further rolling is continued at about 75° or 100° C., when the thickness is reduced to 0·25 in. For certain purposes the rolling may be preceded by drawing, preferably at about 150–200° C.

364,642. H. T. Davies, High Salvington, Worthing, Sussex. [*Classes* 72 and 82(*i*)].

Beryllium Alloys

A calcium-magnesium alloy is used as a reducing agent, with or without a limited amount of aluminium, or an aluminium-magnesium alloy, in a thermo-aluminic method of making aluminium-free alloys of beryllium with heavy metals, such as copper, iron, nickel and cobalt. The mixture may include lime, fluorspar, alumina, etc., to obtain a more fluid slag.

384,243. I. G. FARBENINDUSTRIE AKT-GES., Frankfort-on-Main, Germany. [*Class* 8 (*i*)].

Some Recent Contracts.

Substantial contracts have recently been placed with British manufacturers by the South African Railways and Harbours Administration. The contracts embrace about 17,000 tons of steel rails and fishplates, which are required for 110 miles of track. The orders for about 15,700 tons of 96-lb. steel rails and fishplates, for 100 miles of track, has been allotted as follows :—Cargo Fleet Iron Co., Ltd., Middlesbrough, 30 miles ; British Iron and Steel Co., Ltd., Port Talbot, South Wales, 30 miles ; Dorman, Long and Co., Ltd., Middlesbrough, 20 miles ; and the Barrow Hæmatite Steel Co., Ltd., Barrow-in-Furness, 20 miles. An order for approximately 1,300 tons of 80-lb. steel rails with fishplates has been placed with the Lancashire Steel Corporation, Ltd., of Irlam, Manchester.

Further contracts for 200,000 steel sleepers for use with 80-lb rails, and for 200,000 steel sleepers for use with 60-lb. rails, have been placed with Continental steel manufacturers, while orders for rail and sleeper accessories have been awarded as follows :—Guest, Keen and Nettlefolds, Ltd., Newport (Mon.), fishbolts for both classes of rails ; North West Rivet, Bolt, and Nut Factory, Ltd., Airdrie, Scotland, bolts for sleepers for 80-lb. rails ; Guest, Keen and Nettlefolds, Ltd., Darlaston (Staffs.), bolts for sleepers for 60-lb. rails ; Tees Side Bridge and Engineering Works, Ltd., Middlesbrough, clips for both types of sleepers ; Guest, Keen and Nettlefolds, Ltd., Darlaston, 320,000 fishbolts for special fishplates. Orders for 130,000 pairs of special type of fishplates have been equally divided between Colvilles, Ltd., Motherwell, Scotland, and the Lancashire Steel Corporation, Ltd., Irlam, Manchester.

Metropolitan-Vickers Electrical Co., Ltd., Manchester, have been awarded contracts of an approximate value of £250,000. They comprise 26 motors, each of 2,500 h.p., with the greater part of the control equipment for 26 electric locomotives for the Hungarian State Railways.

Sir Wm. Arrol and Co., Ltd., of Glasgow, have been awarded the contract for a 150-ton, and also a 15-ton overhead electric travelling crane, at a total cost of £6,062, for the Pirjohn electric power station of the Swansea Corporation.

Sir W. G. Armstrong, Whitworth and Co. (Engineers), Ltd., have been awarded an order for a 250-h.p., 40-ton Armstrong-Sulzer Diesel-electric shunting locomotive by the London Midland and Scottish Railway Company. This locomotive is for service in the London district, and will be built at Scotswood-on-Tyne.

Sir W. G. Armstrong, Whitworth and Co. (Engineers), Ltd., Newcastle-on-Tyne, have received an order for the construction of a complete oil-electric train unit for the San Paulo (Brazilian) Railway Co., Ltd., of Gresham House, London, E.C. 2. This train, which will be built at the Scotswood-on-Tyne works, is intended for service on a 50-mile section of the San Paulo railway between Santos and Soa Paulo.

Contracts have been placed for the building of three new ships, each of about 7,000 tons deadweight, by Sir Joseph Isherwood, of Messrs. Isherwood and Co., Ltd. These vessels are to be built on a new system which is expected to result in substantial economies in operation. The vessels are to be built by Lithgows, Ltd., Port Glasgow ; Furness Shipbuilding Co., Ltd., Middlesbrough ; and Short Brothers, Ltd., Sunderland.

Messrs. Lithgows, Ltd., Port Glasgow, have received an order for two vessels of 8,500 tons deadweight. The machinery for these vessels will comprise triple-expansion engines developing about 2,500 h.p., and will be supplied by David Rowan and Co., Ltd.

The Cambridge Instrument Co., Ltd., of 45, Grosvenor Place, London, S.W. 1, has recently received an order from the Admiralty for 24 Cambridge recording and indicating electrical CO_2 meters to be installed in the Royal Naval Cordite Factory at Holton Heath.

Messrs. Harland and Wolff, Ltd., have received an important contract from Messrs. Iraq Petroleum Co., Ltd., for 16 Diesel engines, each of 500 h.p., of the four-stroke, single-acting, airless-injection type, for five of the pumping stations on the Iraq pipe line. The building of the engines is being carried out at the company's Diesel engine works, at Glasgow.

Barrow Steel Co. has received an order for steel rails. It forms part of a number of orders placed with British firms for steel rails by the Chinese Government, which represent a value of approximately £50,000.

The Admiralty announce that the contract for the hull and machinery of the destroyer depot and repair ship, *Woolwich*, authorised by the 1932 Navy Estimates, has been entrusted to the Fairfield Shipbuilding and Engineering Co., Ltd., of Govan, Glasgow. Two other vessels of the 1932 programme have been assigned to Vickers-Armstrong, Ltd., and Cammell Laird and Co., Ltd., for the 1,800-ton submarine *Clyde* and the 640-ton submarine *Salmon*, respectively.

A contract for the construction of two dispatch boats and two submarines for the Portuguese Navy, and the supply of war material, has been signed by representatives of the Portuguese Government and British firms headed by Vickers-Armstrong, Ltd.

West's Gas Improvement Co., Manchester, have received a contract for an extension to one of the chief gas works in Copenhagen. It includes a large installation of the firm's latest type of carbonising plant. The contract is stated to be valued at £150,000.

Harland and Wolff, Ltd., Belfast, have received an order for a twin-screw passenger and cargo vessel from the Bombay Steam Navigation Co., Ltd. The vessel will be about 200 ft. long and will have two sets of triple expansion engines. It is proposed to construct the vessel at the Company's Govan shipyard, the machinery being made at Belfast.

Sturtevant Engineering Co., Ltd., London, have received an order for two electrostatic precipitation plants for the removal of grit from flue gases of pulverised-fuel-fired boilers at a large London power station.

Ruston and Hornsby, Ltd., of Lincoln, have received instructions to put in hand eight auxiliary generating sets, each of 100 k.w., for installation in two first-class passenger vessels now under construction at the Belfast yard of Workman, Clark (1928), Ltd. The engines will be five-cylinder units working on the Ruston principle of airless injection.

Dorman, Long and Co., Ltd., Middlesbrough, have been awarded contracts for the supply and erection of the steel framework for cinemas at Nottingham (600 tons) and Mitcham (350 tons).

S. P. Austin and Son, Ltd., Sunderland, have received orders for two colliers from William Cory and Son, Ltd., London, one of 1,320 tons deadweight and the other of 3,800 tons deadweight. The engines will be supplied by the North Eastern Marine Engineering Co., Ltd., at Sunderland.

Worthington-Simpson, Ltd., Newark-on-Trent, have received an order from the Iraq Petroleum Co., Ltd., for 45 large pumps, each of which will be driven by a 500-h.p. Diesel engine. These are required for pumping oil through 1,200 miles of the Iraq Co.'s oilfields east of the Tigris to Haifa and Tripoli.

The Woodhall-Duckham Vertical Retort and Oven Construction Co. (1920), Ltd., have received a contract from the Bolton Gas Committee for improvements to the gas works.

Craven's Railway Carriage and Wagon Co. have received an order for 30 steel underframes for tramcars from the Sheffield Corporation Tramways Committee.

Cochrane and Sons, Limited, ship builders, of Selby, have booked an order for a steam trawler for the Hull Fishing Company.

Business Notes and News

Finance for Light Industries.

To help the establishment of light industries on Tyneside a scheme has been launched by 13 prominent business men of the area, by which a company, with a capital of £20,000, is to be formed to finance such industries. With a number of friends, these business men are prepared to provide nearly half the initial capital. While the new company's principal interests will be concentrated in the Tyne area, there will be nothing in its articles to preclude its assisting approved undertakings anywhere in the north-east. The initial capital is not very large, but it should be enough to accomplish something concrete without delay. Thereafter, the company will be able to develop with the industries introduced.

As a rule, finance is the chief difficulty with which any new industry is faced, and this scheme seems to be an excellent method of providing it. Local business men are clearly well suited to judge whether any particular business has a good chance of success and, once it has been started, they are able to keep watch on its activities.

New Type Oil Tanker.

An order for an oil tanker barge for Canadian owners has been secured by Messrs. Swan Hunter and Wigham Richardson, of Wallsend-on-Tyne. This order has a special interest, and may mark the beginning of a new era of shipbuilding practice.

There will be hardly a rivet, a caulked seam, or a punched hole in the frames or fabric of the vessel. Frames will be built up by welding and the shell plating will be welded to the frames.

Dock Extension at Southampton Nearing Completion.

Including the largest graving dock in the world and an ocean quay capable of berthing simultaneously eight of the greatest ships afloat or contemplated, the completion of the extension of the Southern Railway's Southampton Docks is expected before the end of this year. The ocean quay was begun in 1927. The graving dock was sanctioned in November, 1930, and this part of the scheme is likely to be finished during the summer months.

Beyond these extensions, which will cost approximately £13,000,000, further works of equal or greater magnitude are contemplated in the future, including a new jetty about a mile long and a second graving dock similar to that now being built. The jetty will have berths aggregating some 10,000 ft., and a depth of water alongside of from 40 to 45 ft.

The first of the principal works at present in various stages of completion is the construction of an ocean quay extending some 7,500 ft., which will enclose the wide bay in the river abreast of Southampton West station. This quay will be completely equipped with a line of passenger and cargo sheds, each 150 ft. wide and over a mile in length collectively. They and the quay berths will be served by a main line railway approach, sidings, roadways, and cranes.

The Discoverer of Oxygen.

Joseph Priestley's Bi-Centenary.

Celebrations are now in progress by the Royal Society, the Chemical Society, the Priestley Club of Leeds, and other learned, industrial, and philosophical bodies, of the bi-centenary of the birth of Dr. Joseph Priestley, the discoverer of oxygen.

Born on March 13, 1733, Priestley was the son of a farmer and woollen manufacturer. He was trained for the Unitarian Ministry, at Daventry, and went to his first pastorate at Needham Market in Suffolk in 1755, afterwards removing to Nantwich, in Cheshire, and becoming a tutor at Warrington Academy.

While he will always be remembered and honoured as the discoverer of oxygen, it must be remembered that for more than a century oxygen remained a laboratory product, utilised for research purposes, and obtained mainly by chemical reactions.

It was not until 1886 that the successful separation of oxygen from the atmosphere gave birth to the great oxygen producing industry, which has to-day penetrated to every civilised quarter of the globe. The commercial development of oxygen is undoubtedly due in a large measure to the British Oxygen Co., as it was in 1886 that this company opened a small factory for the abstraction of oxygen from the atmosphere by a method which became known as the barium oxide process.

Early in the present century the production of liquid air and the important researches of Professor Carl von Linde, in Germany, pointed to a method of separating oxygen from the other constituents of the atmosphere which was likely to develop into a successful rival to the barium oxide process, chiefly because it was capable of producing oxygen of greater purity. The British Oxygen Co., therefore, under arrangement with Professor Linde, and after a prolonged investigation, gradually began to replace their old plants with others employing the air liquefaction method of producing oxygen, and that system in various forms is now almost universally employed.

Gold Mines to be Reopened.

Gold mines which were worked during the Roman occupation and intermittently down the centuries until 1910 are expected to be reopened shortly in Carmarthenshire, West Wales.

A lease for 60 years to work the minerals has been secured, the intention of the promoters of the operations being to restart the shaft which yielded good results up to pre-war days.

Thorough investigations have been made and the promoters are satisfied that there are reasonable prospects of success. The engineer in charge of operations in 1910 is also associated with the new venture.

Modern equipment, including powerful pumps, is to be installed and the shaft will be driven to the lower strata, the former workings having been near the surface. Some 40 men will probably be engaged almost immediately and the number increased according to results achieved.

The mines which bear the picturesque Welsh name Ogofau Caves, are situated near a noted Welsh mansion amid beautiful surroundings.

The International Aluminium Competition Results

The second competition organised at the beginning of 1932 by the International Aluminium Bureau, with the object of encouraging development in the application of aluminium and its alloys, has met with a better response than that of 1931 in the technical circles of most countries. More than 1,000 persons addressed inquiries to the Bureau International de l'Aluminium as to the details of the competition, and 405 memoranda were received, which, in the great majority of cases, were based on serious investigations, and showed an expert knowledge of the light metals.

The competition was open to technical workers in every part of the world, and 20,000 Swiss francs was allocated for the prize money. Two proposals were considered by the jury to have superior interest, and these were awarded 4,000 francs each. They referred to researches on the protection of aluminium and its alloys by the M.B.V. process and the improvements made in this process and on the use of aluminium alloys in gas or oil fired central-heating plant. The entry dealing with the M.B.V. process was submitted by Dr. Eckert, of Grevenbroich, Germany; that on central-heating plant being submitted by M. Phillippe, of Paris.

Two second prizes of 3,000 francs each were awarded to Mr. F. Hirakawa, of Yawata, Japan, for his article on aluminium tuyères for blast-furnaces; and to Mr. Th. Schweizer, of Zurich, Switzerland, for his memorandum on the use of aluminium for grain silos. In addition to the foregoing, three prizes of 2,000 francs each were awarded to M. Py, of Paris; Mr. Steinborn, of Rodange, Luxemburg, and M. H. Tatu, of Lyons, France, for suggestions regarding an improved model of an aluminium-alloy bicycle; the possibilities of the use of aluminium and its alloys in blast-furnace and steel works; and their use in dyeing and cleaning, respectively.

Tube Strip for Russia.

Following an order for 10,000 tons of tube strip from the Russian Soviet Government in 1931, the Newport (Monmouthshire) firm of Messrs. Whitehead Iron and Steel Co., Ltd., have now been asked to supply a further 5,000 tons.

The Courtybella works of the company is working to full capacity, and the new order will ensure a continuance of that satisfactory position for some months to come. Shipments are made from Newport Docks.

British Standard Specifications

British Standard Plugs and Sockets.

From time to time complaints have been raised regarding the behaviour of wall plugs and sockets, more particularly as regards overheating of the contacts and looseness (or tightness) of the contact between the pins and their sockets. These defects have been attributed to the fact that the tolerances on the diameters of the pins and contact-tubes are not always rigidly adhered to, but in many designs the problem has been met by introducing a spring form of construction for the contacts in the socket, and also by making these contacts "floating"—*i.e.*, self-adjusting as to pitch. These features have now been incorporated as mandatory requirements in the British Standard Specification for wall plugs and sockets (B.S.S. No. 372), and a revision sheet to this effect has just been issued. Copies of this sheet, issued under reference C.C. (EL) 9,440, will be supplied by the Publications Department of the British Standards Institution, 28, Victoria Street, London, S.W. 1, on receipt of a stamped envelope.

Light Aluminium Alloy Bars.

For some years the light alloy industry has been familiar with the specifications Nos. 3 L. 1 and 2 L. 25 for wrought bars in the two alloys generally known as Duralumin and Y-Alloy. These two specifications were prepared having regard to the use of this material for aircraft purposes, and the British Standards Institution has now issued two corresponding B.S. Specifications, Nos. 477 and 478, respectively, dealing with the quality and properties of these alloy bars for general engineering purposes.

The Committee responsible for the drafting of these two specifications was constituted as follows:—Dr. L. Aitchison (Chairman), Com. C. G. Procter, R.N., Admiralty; Dr. H. Moore, C.B.E., War Office; Mr. W. Hardy, Air Ministry; Mr. S. L. Archbutt, National Physical Laboratory; Mr. L. E. Benson and Mr. W. B. Parker, British Electrical and Allied Manufacturers' Association; Dr. O. F. Hudson, British Non-Ferrous Metals Research Association; Mr. E. Sellman, British Aluminium Holloware Manufacturers' Association; Mr. J. B. Hoblyn, Institution of Automobile Engineers; Mr. W. H. Clarke, Mr. W. J. Clements, Mr. W. C. Devereux, Dr. A. G. C. Gwyer, Mr. G. H. Field, Mr. F. W. Thomas, and Mr. F. Tomlinson, representing the manufacturers interested in the alloys; and Dr. W. Rosenhain.

The specifications, as is usual with the British Standard Specifications for non-ferrous alloys, detail the compositions of the alloys and their mechanical properties, and include clauses relating to the provision of test samples and the form of test pieces. Dimensions and tolerances are standardised, whilst in an appendix to each specification are given some helpful notes relating to the preparation and heat-treatment of the respective alloys.

The specifications for Duralumin cover the requirements of the machinist, and also of the drop forger, and provide for the material as used largely in the automobile industry, and for the heavier forms of transport, such as railway vans, and steamships. The "Y" alloy specifications cover a material used for those parts of internal combustion engines that are exposed to elevated temperatures in service.

Copies of these specifications (Nos. 477 and 478-1933) may be obtained from the Publications Department of the Institution, 28, Victoria Street, London, S.W. 1, price 2s 2d. *each*, post free.

Paper-Insulated Cables for Electricity Supply.

Probably one of the most well-known British Standard Specifications amongst members of the electrical industry is that for cables, and the new specification just published as No. 480, dealing with paper-insulated cables, is, therefore, of more than usual interest. This specification supersedes B.S.S. No. 7-1926 in so far as the latter relates to paper-insulated cables, and the changes now introduced are so important that B.S.S. 480-1933 is virtually a new specification, although nominally a revision of a portion of B.S.S. No. 7-1926.

The main modifications, as compared with B.S.S. No. 7-1926, relate to the thicknesses of insulation and metallic sheath. In the first place, the method of stating these thicknesses is new; and in the second place, the actual thicknesses have been reduced. At the same time it should be borne in mind that there have in recent years been considerable advances in the technique of cable-making, and there need be no fear that the factor of safety has been unduly affected. The reductions in the thicknesses of insulation and metallic sheath are not so great as would appear from a first glance at the tables, since the new figures represent minimum thicknesses at any point in the wall of the cable, whereas in the 1926 specification, a tolerance of 10% below the thicknesses stated in the tables was permitted provided that the mean of the thicknesses around the circumference was not less than the standard value.

The new specification introduces, for the first time, tables of dimensions for 460-volt and 20,000-volt cables. An appendix is also included giving a schedule of recommended colours for the cores of paper-insulated cables. It is recommended that these colours should be adopted as far as possible in new installations.

Business Notes and News—continued.

Contracts Pending for Corby Developments.

Many branches of the engineering trades will benefit from contracts to be placed shortly in connection with Stewarts and Lloyds new £3,000,000 steel and tube works at Corby, Northants. Inquiries have been sent out for the coke oven plant and other important units of equipment for these works The consulting engineers, Messrs. H. A. Brassert and Co., of London, are preparing the detailed plans for these works and rapid progress is being made. The site is being levelled and the laying of railway sidings has begun.

Originally it was intended to put down new furnaces at these works, but it has now been decided to modernise the existing plant to render it capable of producing the large quantities of iron which will be necessary. With this object steps have been taken to reconstruct one of the three blast-furnaces at Corby.

Air Ministry Contract for Petrol from Coal.

There is considerable interest behind the recent official announcement that the Air Ministry has placed a contract for twelve months' supplies of a new type of aviation petrol made from coal. The petrol is produced by Low Temperature Carbonisation, Ltd., as a by-product in the manufacture of a smokeless fuel, and is refined by Messrs. Carless, Capel and Leonard, of London.

This is the first order of its kind placed by the Air Ministry, and the quantity ordered will be sufficient for ample flying tests. An entire home defence squadron equipped with high performance fighting machines is now flying solely on coal petrol. Colonel W. A. Bristow, managing director of Low Temperature Carbonisation, Ltd., announced that his company foresee the possibility of supplying the Royal Air Force in course of time, if required, with all the petrol it needs. This company has for some time past been producing from Yorkshire coal a petrol of outstanding quality and performance.

National Federation of Iron and Steel Manufacturers.

At the recent annual meeting of the National Federation of Iron and Steel Manufacturers, Mr. James Henderson, deputy chairman and general manager of the Frodingham Iron and Steel Co., was elected president for 1934, and the following were elected vice-presidents:—Sir John Beale, chairman of Messrs. British (Guest Keen Baldwins) Iron and Steel Co., Captain R. S. Hilton (managing director of the United Steel Companies), Mr. Charles Mitchell (chairman of Messrs. Dorman, Long & Co.), and Mr. Ben Walmsley (director of Messrs. Dorman, Long & Co.).

Merger Negotiations on Tees-Side.

For some time a plan has been under consideration regarding the merging of three Tees-side firms, and it is understood that negotiations have reached a final stage. The firms comprise Messrs. Dorman Long, Ltd., South Durham Iron and Steel Co., Ltd., and Cargo Fleet Iron Co., Ltd.

A capital of over £20,000,000 is concerned in this prospective merger, which, if successfully accomplished, will place the iron and steel industry on the Tees-side practically under one control. In normal times the companies involved employ about 32,000 men.

Electric Arc Welding in Ship Construction

By J. L. Adam.

Increasing interest is being shown in the application of welding to ship construction, and every branch of the industry must be thoroughly explored so that practice may be placed on a sound basis.

DURING the last two or three years there has been a distinct revival of interest in welding for ship work in this country; as a consequence welding has been much more widely used, and where this has been the result of careful consideration of all relevant factors it has, in shipbuilding, as in other industries, justified itself economically and technically. It is probable that both technical and economical exigencies will force an even wider adoption of welding in ship structures, and, therefore, the more thoroughly every branch of the subject is explored, and the merits and demerits of welding are understood, the more quickly will practice be placed on a sound basis. In a paper on the subject, given before the Institute of Engineers and Shipbuilders of Scotland recently, the author appreciated the difficulty of dealing adequately with all the aspects of welding. In this paper he confined himself to references to the metallurgical aspect as affecting certain features of design or construction. Definite information about welding and welded connections has been obtained from tests, and experiments and a short summary of the leading characteristics are included as being essential to a practical understanding of the subject.

Practical experience and tests have shown that with normally skilled shipyard operators—that is, sufficiently skilled to lay down a given number of inches from a given electrode, after one or two trials of that particular type of electrode—there is only from 10% to 12% variation in the results obtained from a number of test-pieces made to a given specification, and there is very little or no greater difference between the test-pieces made by different operators from the same specification. There must, obviously, be a certain discretion in checking operations. If the terminals on the regulators are clearly marked, and the current frequently checked at these terminals, the work of an operator on a particular type of weld can be checked with reasonable accuracy at any time by checking the current, both at the regulators and near the operators, the size and type of electrode, and the linear inches deposited from the electrodes in the runs done and being done. If this procedure is combined with competent inspection of the welding for workmanship, etc., it is possible to form a very close estimate of the degree of uniformity obtained, and to know whether assurance as to the soundness of the welding is justified.

If the welding of all-welded ships, or of important parts of the structure of other ships, is to be effective, very careful consideration must be given to the structural design, the arrangement of the welding material, and arrangements for welding; and if efficiency is to be combined with economy, it is also necessary to study very thoroughly such factors as the convenience and cost of handling raw material and finished products, plant installation, labour requirements, and continuity of operations. It is obvious that the complete hull structure should be made up of preconstructed sections as large as the yard plant can handle, so that the largest possible proportion of the total welding can be done under the best conditions. It is equally obvious that in this country climatic conditions call for as much preconstruction as possible being done under cover if continuity of operations is to be maintained.

So far as future development is concerned, the author is not of those who believe that the only place to develop effective and economic welding in ship construction is in a yard laid out and adapted solely for welding, or that it is neither economical nor practicable to combine welding and riveting in one hull. On the contrary, he believes that the layout and transport facilities of many yards could readily be altered to permit of electric welding being applied to important parts of the structure where its adoption is strongly to be recommended. It has already been suggested that owners would benefit by the more extensive use of effective welding in ordinary ship construction, and the tank margin and bilge construction is a case in point. Every owner knows that margin connections are one of the greatest sources of trouble in a ship, and will agree that a construction which will eliminate cracked margin plates and started rivets in margin and gusset connections is greatly to be desired.

What may be described as haphazard welding has already been referred to, and much might be written about the prejudice created in the minds of some owners by the methods and practice sometimes adopted in repair work welding. As an instance, a certain operator, when on new work or making test-pieces, showed that he was quite competent and that he had due regard to the thermal effects of the rate of deposit, etc., but on repair work he seemed to forget altogether that metallurgical phenomena do not change with the job, and, unfortunately, his foreman knew no better. This too frequently happens, and it is not surprising that some superintendents will only accept welding as a substitute for caulking. Frequently, however, really good welding is not successful because of the failure of those who recommend its use to realise the basic characteristics of welding material and welding. Unless adequate reinforcement is provided welding should never be adopted for repairing the flanges of bars which have been broken or plating which has cracked, due to constant reversals of stress, or concentration of stress. Care should also be taken to avoid concentration of the welding material; that is, heavy welds should not be used if a large number of linear inches of light welding can be substituted.

Before concluding, the author emphasised the fact that welding operations must be systematised in all details if the results are to inspire confidence; automatic welding machines adapted for covered electrodes will do much towards this end, but where they cannot be utilised the uniformity in results they give can be approached by properly controlled hand welding. A supervisor or foreman welder who knows his work (which includes a knowledge of welding plant and its shortcomings, as well as a knowledge of welding) should be able, with proper plant and operators, to provide an effective welded ship structure to-day if, in designing that structure, due regard is paid to the characteristics of welding and welding material.

The Gold Medal of the Royal Aeronautical Society.

The Council of the Royal Aeronautical Society has awarded the Society's Gold Medal to Sir Richard Glazebrook, K.C.B., F.R.S., Fellow of the Society. The Gold Medal is the highest honour which the Society can confer. It has only been awarded six times previously—to the Wright Brothers, Mr. Octave Chanute, Professor Bryan, Mr. E. T. Busk, Professor Lanchester, and Professor L. Prandtl.

Sir Richard Glazebrook has been Chairman of the Aeronautical Research Committee since its foundation in 1909 (as the Advisory Committee for Aeronautics), and is retiring from the position in April next.

MARKET PRICES

ALUMINIUM.

98/99% Purity	£95	0	0

ANTIMONY.

English	£37 0 0 to £42	10	0
Chinese	27	15	0
Crude	19	10	0

BRASS.

Solid Drawn Tubes	lb.	8½d.
Brazed Tubes	,,	10½d.
Rods Drawn	,,	7½d.
Wire	,,	7½d.
*Extruded Brass Bars	,,	3½d.

COPPER.

Standard Cash	£28	10	0
Electrolytic	32	10	0
Best Selected	30	5	0
Tough	29	17	0
Sheets	59	10	0
Wire Bars	32	5	0
Ingot Bars	32	5	0
Solid Drawn Tubes	lb.	9½d.	
Brazed Tubes	,,	9½d.	

FERRO ALLOYS.

‡Tungsten Metal Powder	lb.	0	1	10½
‡Ferro Tungsten	,,	0	1	7½
Ferro Chrome, 60-70% Chr. Basis 60% Chr. 2-ton lots or up.				
NOMINAL 2-4% Carbon, scale 12/- per unit	ton	34	2	6
NOMINAL 4-6% Carbon, scale 7/6 per unit	,,	24	10	0
NOMINAL 6-8% Carbon, scale 7/6 per unit	,,	22	15	6
NOMINAL 8-10% Carbon, scale 7/3 per unit	,,	22	10	6
§Ferro Chrome, Specially Refined, broken in small pieces for Crucible Steel-work. Quantities of 1 ton or over. Basis 60% Ch. Guar. max. 2% Carbon, scale 11/0 per unit	,,	34	15	0
Guar. max. 1% Carbon, scale 13/6 per unit	,,	39	0	0
§Guar. max. 0.7% Carbon, scale 15/- per unit	,,	42	17	6
‡Manganese Metal 96-98% Mn.	lb.	0	1	4
‡Metallic Chromium	,,	0	2	8
§Ferro-Vanadium 25-50%	,,	0	12	8
§Spiegel, 18-20%	ton	7	10	0
Ferro Silicon— Basis 10%, scale 3/- per unit	ton	5	17	6
20/30% basis 25%, scale 3/6 per unit	,,	8	10	0
45/50% basis 45%, scale 5/- per unit	,,	13	15	0
70/80% basis 75%, scale 7/- per unit	,,	19	0	0
90/95% basis 90%, scale 10/- per unit	,,	30	0	0
§Silico Manganese 65/75% Mn., basis 65% Mn.	,,	14	17	6
§Ferro-Carbon Titanium, 15/18% Ti	lb.	0	0	6
Ferro Phosphorus, 20-25%	ton	17	17	6

FUELS.

Foundry Coke—						
S. Wales	£1	0	0 to	1	2	6
Scotland	—			1	10	0
Durham	1	1	0 to	1	5	0
Furnace Coke—						
Scotland	—			1	7	6
S. Wales	0	16	0 to	0	16	6
Durham	0	13	0 to	0	13	6

GUN METAL.

*Admiralty Gunmetal Ingots (88:10:2)	£47	0	0
*Commercial Ingots	37	10	0
*Gunmetal Bars, Tank brand, 1 in. dia. and upwards	lb.	0	0 8
*Cored Bars	,,	0	0 10

LEAD.

Soft Foreign	£11	2	6
English	12	10	0

MANUFACTURED IRON.

Scotland—			
Crown Bars, Best	£10	5	0
N.E. Coast—			
Rivets	11	0	0
Best Bars	10	10	0
Common Bars	10	0	0
Lancashire—			
Crown Bars	9	15	0
Hoops £10 10 0 to	12	0	0
Midlands—			
Crown Bars £9 15 0 to	10	0	0
Marked Bars	12	0	0
Unmarked Bars	—		
Nut and Bolt Bars £8 7 6 to	8	12	6
Gas Strip	10	12	6
S. Yorks.—			
Best Bars	10	10	0
Hoops. Hoops £10 10 0 to	12	0	0

PHOSPHOR BRONZE.

*Bars, "Tank" brand, 1 in. dia. and upwards—Solid	lb.	8d.
*Cored Bars	,,	10d.
†Strip	,,	10½d.
†Sheet to 10 W.G.	,,	10½d.
†Wire	,,	11½d.
†Rods	,,	10½d.
†Tubes	,,	1/3½
†Castings	,,	1/1½

†10% Phos. Cop. £30 above B.S.
†15% Phos. Cop. £35 above B.S.
†Phos. Tin (5%) £30 above English Ingots.

PIG IRON.

Scotland—			
Hematite M/Nos.	£3	6	0
Foundry No. 1	3	10	0
,, No. 3	3	7	6
N.E. Coast—			
Hematite No. 1	3	0	0
Foundry No. 1	3	1	0
,, No. 3	2	18	6
,, No. 4	2	17	6
Cleveland—			
Foundry No. 3	2	18	6
,, No. 4	2	17	6
Silicon Iron	3	1	0
Forge No. 4	2	17	0
Midlands—			
N. Staffs Forge No. 4	3	1	0
,, Foundry No. 3	3	6	0
Northants—			
Forge No. 4	2	17	6
Foundry No. 3	3	2	6
Derbyshire Forge	3	1	0
,, Foundry No. 3	3	6	0
West Coast Hematite	3	6	0
East ,, ,, No. 1	3	0	0

SWEDISH CHARCOAL IRON AND STEEL.

Kr. per English ton @ 18-16 to £1 approximately.

Pig Iron Kr. 92	—
Billets Kr. 280-290	£15 10 0-£16 0 0
Wire Rods Kr. 265-320	£14 12 6-£17 12 6
Rolled Bars (dead soft) Kr. 185-210	£10 4 0-£11 11 0
Rolled Charcoal Iron Bars Kr. 290	£16 0 0

All per English ton, f.o.b. Gothenburg.

SCRAP METAL.

Copper Clean	£21	0	0
,, Brazery	19	0	0
,, Wire	—		
Brass	16	0	0
Gun Metal	18	0	0
Zinc	8	10	0
Aluminium Cuttings	74	0	0
Lead	9	0	0
Heavy Steel—			
S. Wales	2	5	0
Scotland	1	18	6
Cleveland	2	5	0
Cast Iron—			
Midlands	2	0	0
S. Wales	2	5	0
Cleveland	2	5	0
Steel Turnings—			
Cleveland	1	12	6
Midlands	1	6	6
Cast Iron Borings—			
Cleveland	1	3	6
Scotland	1	12	0

SPELTER.

G.O.B. Official	—		
Hard	£11	17	6
English	15	7	6
India	14	0	0
Re-melted	14	0	0

STEEL.

Ship, Bridge, and Tank Plates—			
Scotland	£8	15	0
North-East Coast	8	15	0
Midlands	8	17	6
Boiler Plates (Land), Scotland	9	0	0
,, ,, (Marine) ,,	—		
,, ,, (Land), N.E. Coast	10	0	0
,, ,, (Marine) ,,	10	10	0
Angles, Scotland	8	7	6
,, North-East Coast	8	7	6
,, Midlands	8	7	6
Joists	8	15	0
Heavy Rails	8	10	0
Fishplates	12	0	0
Light Rails £8 10 0 to	8	15	0
Sheffield—			
Siemens Acid Billets	9	2	6
Hard Basic £8 2 6 and	8	12	6
Medium Basic £6 12 6 and	7	2	6
Soft Basic	6	0	0
Hoops £9 10 0 to	9	15	0
Manchester—			
Hoops £9 0 0 to	10	0	0
Scotland, Sheets 24 B.G.	10	5	0

HIGH SPEED TOOL STEEL.

Finished Bars 14% Tungsten	lb.	2/-
Finished Bars 18% Tungsten	,,	2/9
Extras		
Round and Squares, ⅛ in. to ½ in.	,,	3d.
Under ¼ in. to ⅛ in.	,,	1/-
Round and Squares 3 in.	,,	4d.
Flats under 1 in. × ⅛ in.	,,	3d.
,, ,, ½ in. × ¼ in.	,,	1/-

TIN.

Standard Cash	£149	0	0
English	150	5	0
Australian	152	5	0
Eastern	153	10	0
Tin Plates I.C. 20 × 14 box	0	16	0
Block Tin (Cash)	148	10	0

ZINC.

English Sheets	£24	0	0
Rods	26	0	0
Battery Plates	—		

* McKechnie Brothers, Ltd., quoted March 9. † C. Clifford & Son, Ltd., quoted March 9. ‡ Murex Limited, quoted March 9.
Subject to Market fluctuations. Buyers are advised to send inquiries for current prices.
§ Prices quoted March 9, ex warehouse.